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THE EMERGENCY TREATMENT OF BONE AND JOINT CASUALTIES *

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Each of your presidents has brought you a message which he has considered of importance and interest to this group. My predecessor in office rendered an account of his stewardship by presenting a clear, forthright analysis of the affairs of The American Academy of Orthopaedic Surgeons. I shall attempt to impress upon you, as bone and joint surgeons, certain experiences in the emergency treatment of bone and joint trauma which many of you have shared.

Having served in a French ambulance corps in 1914, and later with our Expeditionary Forces in France in 1918, I saw the utter confusion, lack of planning, and the indifferent emergency military surgery which was all too frequently practised in our inadequately supervised military hospitals at that time.

During the Meuse-Argonne offensive, I served in a 500-bed Evacuation Hospital which had never functioned before. The officers and enlisted personnel were quite untrained for the task at hand. The reception of 1,200 wounded in a twenty-four-hour period resulted in complete chaos in the command and in the professional service of that Hospital, with needless suffering endured by our soldiers.

During World War I, some unusually brilliant surgery was performed on the wounded by a few of our distinguished surgeons and also by the surgeons of our Allies. Our participation in that War, as the First United States Army, lasted only from September 2 to November 11, 1918,—a little more than two months of actual combat under our own command. For a year before this, several of our infantry divisions had served under the French or British command, and some of our affiliated Base Hospitals were in active operation.

As far as our Army was concerned, the War was over before the medical or surgical consultants under the Chief Surgeon could secure anything approaching adequate emergency care of the wounded in many instances. Valuable experience gained by some of our foremost surgeons, in the treatment of battle casualties, was not relayed to our outlying hospitals.

A brief review of what the top-flight treatment of battle casualties involving bones and joints was in 1918 is at once illuminating and discouraging, when we remember how hesitatingly we faced the problem in 1941, 1942, and 1943.

Immediate and delayed primary closure of wounds was practised during World War I to a limited extent. The following is a quotation from the British official history of the war [6]:

"The treatment of wounds by free excision . . . was generally adopted . . . after 1915. . . . The earlier this treatment was carried out and the more thorough the removal of all torn muscle and foreign bodies, the more satisfactory were the results. . . . It was found to be most important not to excise any skin, although free incisions to get at the deeper parts were commonly required."

* Delivered as the Presidential Address at the Seventeenth Annual Meeting of The American Academy of Orthopaedic Surgeons, New York, N. Y., February 14, 1950.

"*Suture of Wounds:* The wounds treated by suture in the early days of the war did badly, and as a result, the closure of wounds fell into complete disuse. . . . In 1917 suture was again tried, but then only under good aseptic conditions and after the excision of damaged tissues and the removal of all foreign bodies, and it was soon found that under these circumstances very good results could be obtained."

"At No. 22 General Hospital, out of a series of 5,539 wounded who had arrived in August and September 1918, after an interval of forty-eight hours since being wounded, 741 cases were treated by primary suture, and 192 by delayed primary suture. Of the primary sutures 88 per cent. were successful in spite of the fact that either bones or joints were involved in no less than 184 patients. Of the delayed primary sutures, 81 per cent. were successful."

Colonel Joseph A. Blake, one-time Professor of Surgery at the College of Physicians and Surgeons, Columbia, early in 1918 wrote on gunshot fractures of the extremities. He described the treatment of wounds over these fractures by laying them *wide open*, excising adequately all devitalized tissues, emphasizing the greatest care in removal of bone fragments. He stated: "Care should be taken to leave at least one or more [fragments], if possible, to preserve the continuity of the shaft". "Wounds treated in this way may be closed by primary, delayed primary, or secondary suture."

Colonel Eugene Pool, in 1919, just returned from service overseas, presented two reports, one to the Section on Surgery of the American Medical Association on "War Wounds, Primary and Secondary Suture", and the other to the American Surgical Association on "Treatment of Recent Wounds of the Knee-Joint". In these reports, Colonel Pool stated: "I am convinced that delayed primary suture should be aimed at in most compound fractures of the long bones. . . ." It "can be done with few failures and little risk". In speaking of débridement of the compound fracture, Pool stated: "The temptation to remove fragments [of bone] freely should be resisted." "Wounds of the hands should, as a rule, be sutured"; by that he meant immediate primary suture.

In wounds of the knee joint, Colonel Pool advocated adequate débridement, immediate closure of the capsule of the joint, and delayed primary closure of the overlying skin.

All these observations were predicated on a sizable series of patients treated and the fundamental adequate surgical excision of all devitalized muscle and other soft tissue, with removal of all foreign bodies. This superb surgical treatment of war wounds was accomplished *without* benefit of sulfonamides, penicillin, or other antibiotics.

Working in an indifferently staffed Evacuation Hospital, I neither saw nor heard of closure of wounds. As a matter of fact, closure was *not* resorted to frequently by any large number of surgeons.

The compound fractures caused by various missiles were treated by skeletal traction in our Base Hospitals. Daily dressing of the open wounds and continuous irrigation with a weak solution of sodium hypochlorite (Dakin's solution) was the practice. Ambrose Paré's saying, "I dressed him; God healed him", held a poignant meaning for the medical officers serving on these fracture wards, not to mention the wounded soldiers who received their ministrations.

This priceless information regarding adequate treatment of wounds involving bones and joints remained buried or forgotten between the two World Wars, and in consequence we started World War II with no clear-cut idea of procedure for the emergency treatment of bone and joint casualties.

In 1942, under the auspices of the National Research Council, a military surgical manual on orthopaedic subjects [8] was prepared to furnish "essential up-to-date and reliable information regarding military surgery". This is a well written text by distinguished authors, a majority of whom had served as medical officers in World War I. With a few exceptions, this book is merely a useful compendium of various reconstructive bone and joint procedures for fixed hospitals in the Zone of the Interior.

Acute hematogenous osteomyelitis absorbed eighty-nine pages, almost a third of the text; yet during my visits to some 300 hospitals in the Zone of the Interior and overseas, I saw no soldier with this disease.

The manual was practically devoid of suggestions for the care of battle casualties involving bones and joints in a theatre of operation. Skeletal traction in the treatment of compound fractures, amputation, delayed primary closure of wounds over compound fractures, the emergency treatment of wounds involving joints, and the wounded hand, which were among the chief concern of the bone and joint surgeon overseas, received no mention.

A débridement or wound excision was well described. The importance of splinting the compound fracture was emphasized, but then the remark was made: "Splints can be improvised at the scene of the accident if they are needed". This observation, of course, fails to take cognizance of the fact that at any given point there may be need for hundreds or thousands of these improvisations.

I should like to show that, having been inadequately briefed for the job of emergency military surgery, and with uncertainty rampant, we had to learn all over again the hard way, and to emphasize what was finally accomplished.

Delayed Primary Closure of Wounds over Compound Fractures

Experiments in primary closure of wounds had been conducted in the European Theatre of Operations long before the Normandy Invasion, at the Second Evacuation Hospital, which was serving the Air Force in East Anglia.

Colonel William F. MacFee reported a series of 257 wounds, including forty-seven compound fractures, treated by débridement and immediate primary closure. The wounded had received sulfonamides. There were only nine infections. Colonel Elliott C. Cutler, Colonel Paul C. Morton, and Major William R. Sandusky reported on 146 patients with 250 wounds, including sixty-six compound fractures. Approximately half of these patients received penicillin before operation, and for forty-eight to seventy-two hours after operation. The antibiotic agent was also used locally in this group. The other half of the patients, a control group, received no penicillin. (This antibiotic agent was then in very short supply.) These parallel series of wounds were carefully debrided with adequate incisions and were closed by immediate primary suture. The incidence of infection was practically identical in each series,—a little under 9 per cent. The one common factor in these three groups of cases was the careful, but adequate, wound excision and immediate primary closure.

These medical officers then expressed the opinion that these airmen, with ample facilities to bathe and to obtain clean clothes, having sustained their wounds at high altitudes in clean surroundings, represented a special circumstance which did not pertain to the ground-force troops.

We all had the feeling that immediate primary closure of wounds on ground-force personnel, who were unwashed, with dirty clothes, and in contact with the heavily manured soil, would be foolhardy. When we turn back twenty-five years and find that immediate primary closure had been done on ground-force troops, similarly unwashed and exposed to the same terrain—with a high degree of success—we must question our judgment. The completeness of the wound excision is unquestionably the determining factor.

We were committed to a policy of delayed primary closure, and continued it throughout the campaign. After the invasion of the Normandy Beachhead, it was relatively easy to persuade the surgeons of our overseas General Hospitals to close soft-tissue wounds, but, in many instances, great reluctance was shown to close these wounds over compound fractures. *The closed circular-plaster technique*, popularized in the Spanish Civil War and earlier, with healing the hard way, had become a deeply ingrained surgical concept.

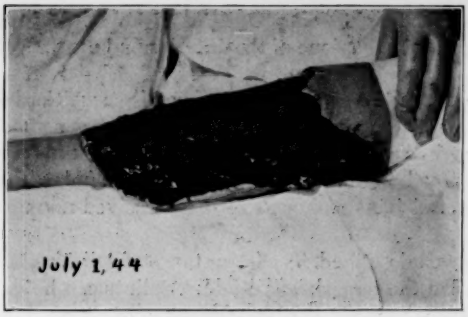

FIG. 1-A

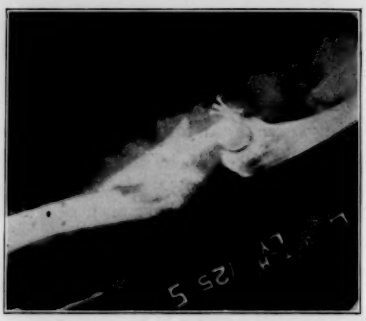

FIG. 1-B

FIG. 1-C

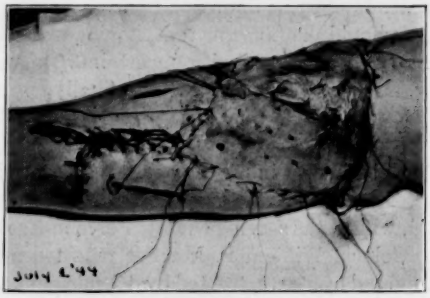

FIG. 1-D

FIG. 1-E

Lt. W. G. was wounded on June 25, 1944. He had compound fractures of the humerus and radius, and a lacerated wound of the arm and forearm. Initial débridement was done at the Royal Air Force Hospital. He was admitted to the 91st General Hospital on June 29. On July 1, a second, more extensive, débridement was done, with closure of the wound by suture and split-thickness skin graft. The photograph of July 18 (Fig. 1-E) shows healing, two and one-half weeks after closure. The patient returned to the Zone of the Interior on August 7, 1944.

Delayed primary closure of wounds over compound fractures, by suture or skin graft, converts the fracture from compound to simple. The intact skin promotes rapid healing of soft tissues and bone beneath the closed integument. Bone replacement, if necessary, and the early suture of divided nerves, may be more rapidly accomplished.

We were anxious to evaluate the success of delayed primary closure of wounds over compound fractures, so a study was undertaken at the Fifteenth Hospital Center by Colonel John A. Grove and his various Chiefs of Orthopaedic Surgery [2]. In the five-month period after the invasion, this Center received 5,042 compound fractures, excluding fractures involving the face, skull, and spine with spinal-cord injury. Delayed primary closure was attempted in 2,393 patients,—by suture in 2,087, by skin graft in 236, and by combination of suture and skin graft in 70. The results were distinctly gratifying.

1. *Complete success* or healing by primary intention occurred in 1,592 cases, or 66.5 per cent. of the total.

FIG. 2-A

FIG. 2-B

FIG. 2-C

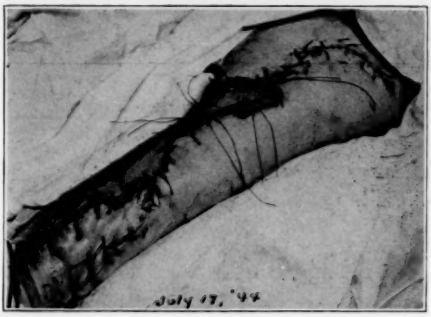

FIG. 2-D

FIG. 2-E

FIG. 2-F

Pvt. V. D. was wounded on June 16, 1944. He had a compound fracture of the right femur, and a lacerated wound in the posterior thigh and buttock. The original débridement was done fourteen hours after injury. He was admitted to the 91st General Hospital on June 20, where a secondary débridement was done and skeletal traction was applied. The wound was closed by suture and split-thickness skin graft on July 16. By August 22, 1944, the fracture was satisfactorily aligned and the wounds had healed.

2. *Partial failure*, a persisting stitch abscess, or partial loss of a skin graft occurred in 640 cases, or 26.7 per cent. of the total. In all but a very few of these partial failures, healing, by a second suture or skin graft or spontaneously, occurred before the patient left the Hospital.

This meant that about 93 per cent. of these patients on whom delayed primary closure of wounds was attempted were returned to the Zone of the Interior with healed wounds.

3. *Complete failure* occurred in 161 cases, or only 7 per cent. of the total. This meant

FIG. 3-A

FIG. 3-C

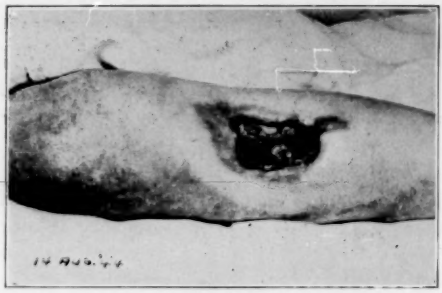

FIG. 3-B

FIG. 3-D

Pvt. E. J. M. was wounded in action on August 5, 1944, sustaining compound fractures of the tibia and fibula. Débridement was done at the 104th Evacuation Hospital the same day. On August 14, closure of the soft-tissue wound was attempted at the 82nd General Hospital. On October 6, a split-thickness graft was unsuccessful. On October 21, a direct cross-leg pedicle graft was applied at the 129th General Hospital. Division of the pedicle was done on November 15, 1944. The patient returned to the Zone of the Interior.

breaking down of the wounds, with development of soft-tissue infection or bone infection which necessitated wide-open surgical drainage.

The success or failure of these closures was determined in all probability by the completeness or boldness of the original wound excision. No peephole débridement will succeed in averting infection.

These results were early, and an inquiry was directed to The Surgeon General, asking if these wounds from the European Theatre of Operations over compound fractures remained healed after the patients returned to the Zone of the Interior. The Ninth Service Command, through Colonel John Loutzenheiser, reported that, in a relatively small series of compound fractures treated by delayed primary closure, received from the European Theatre of Operations, the skin closure remained successful in 73.5 per cent. and the incidence of osteomyelitis was 14 per cent. A series of similar size in which no closure had been attempted showed an incidence of osteomyelitis of 54 per cent. This reduction in osteomyelitis from 54 per cent. to 14 per cent., owing to successful closure of wound—a most important, but by no means the only advantage of delayed closure over compound fractures—should answer the question of how these wounds should be treated.

Colonel Loutzenheiser observed that these findings were essentially similar for all theatres of operations (Figs. 1-A to 4-E).

Treatment of Fractures due to Gunshot or High-Explosive Shell

Skeletal traction is the safest and simplest method of mass treatment of compound fractures of long bones. If evacuation of the patient is planned, as it was in the last War,

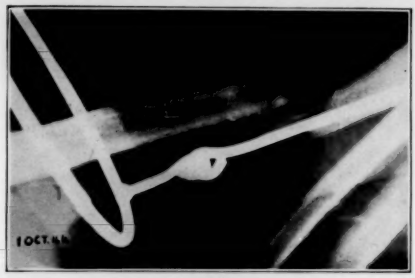

FIG. 4-A

FIG. 4-B

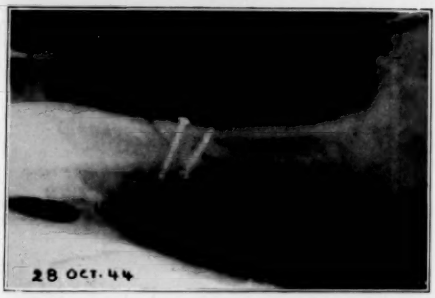

FIG. 4-C

FIG. 4-D

Pfc. C. E. N. was wounded in action on September 22, 1944, sustaining a compound fracture of the right humerus. He had paralysis of the median, radial, and ulnar nerves, a laceration involving the right brachial artery, and gangrene of the tips of the fingers of the right hand. On October 1, skeletal traction was applied through the olecranon. On October 28, a pedicle graft was applied from chest wall to right arm. The humeral fracture was fixed with two screws. Division of the pedicle was carried out on November 21, and a plaster spica was applied. The patient returned to the Zone of the Interior in December 1944.

FIG. 4-E

from an overseas hospital to another hospital in the Zone of the Interior, these fractures should be held in traction long enough to ensure that further displacement will not occur during the transfer in appropriate circular plaster-of-Paris splints. In some instances where it is absolutely necessary, open reduction and internal fixation may be utilized, if the surgeon has been adequately trained. This internal fixation should be undertaken preferably after wound healing.

The efficacy of skeletal traction as a treatment of these long-bone fractures incurred as battle casualties was demonstrated in a report received from The Surgeon General at the request of the Chief Surgeon of the European Theatre. The data for this report were collected in December 1944, so the oldest of these fractures were reported only six months after the wounds had been sustained. The average must have been about four months.

There were 3,190 long-bone compound fractures received from the European Theatre at the nineteen named General Hospitals in the Zone of the Interior, which participated

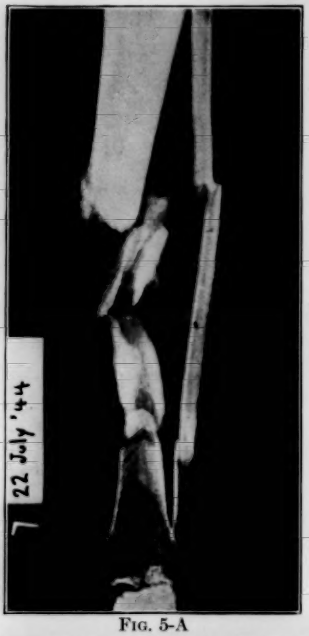

FIG. 5-A

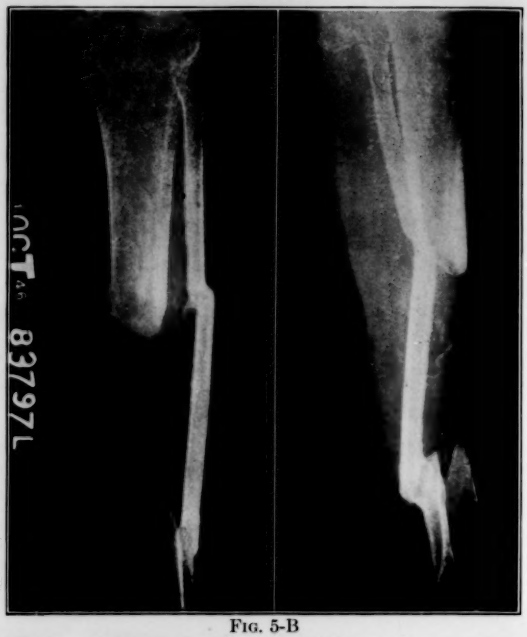

FIG. 5-B

FIG. 5-C

FIG. 5-D

Sgt. M. C. B. sustained compound fractures of the left tibia and fibula and a compound fracture of the left femur on July 22, 1944. On July 29, 1944, débridement was done, with removal of the bone fragments. Infection persisted over a period of two years, and there was marked loss of substance of the tibia. On November 14, 1946, the distal end of the left fibula was transplanted to the left tibia. On April 24, 1947, the left fibula was transplanted to the proximal end of the tibia. On June 23, 1947, a tibial bone graft was applied to the left tibia. In this soldier, with loss of bone substance, healing had not occurred three years after his injury. This is so-called "gaposis".

in this report. The status of healing of these fractures, four to six months after the wounds had been sustained, was as follows:

2,189 or 68.6 per cent. of the fractures were satisfactorily united.
417 or 13.3 per cent. of the fractures had united in malposition.

2,606 or 82 per cent. were united.
584 or 18 per cent. were ununited.

FIG. 6

Front cover and three sample pages from *The Hand Book*, edited by Colonel Philip Foise and illustrated by Sergeant William Pitney, 129th General Hospital.

A considerable number of these ununited fractures must have progressed to union later. A sizable group of them, however, due to loss of bone by the wounding agent or to the overzealous removal of bone fragments, required years of repeated bone-grafting procedures to bridge a gap or loss in continuity, which both Blake and Pool had suggested twenty-five years earlier (Figs. 5-A to 5-D).

The Early Treatment of the Wounded Hand

Wounds of the hand may comprise 2 per cent. of all wounds. It is an accepted fact

FIG. 7-A

FIG. 7-B

Two of the posters utilized in the Hand Wards, 129th General Hospital, to emphasize important use of the hands.

FIG. 8-A

FIG. 8-B

Fig. 8-A: A typical exercise gadget, utilized at the 129th General Hospital to increase motion in stiffened fingers.

Fig. 8-B: Occupational therapy, showing a soldier with two wounded hands, making a knitted scarf.

that the loss of use of the hand is a major catastrophe and, from the time of onset of the wound involving the hand, every intelligent effort should be directed by the military surgeon to salvage all possible damaged tissue and to restore function to as nearly normal as possible. Yet the second World War commenced with no definite program for the treatment of these wounds involving the hand. Aside from Pool's observation that they should be sutured immediately, I know of no plan for their treatment during World War I. There will never be an adequate supply of surgeons thoroughly trained in hand surgery available to military hospitals at home and overseas, in case of another, even greater war. Most of the young surgeons, who have done such remarkable reconstructive surgery of tendons following hand wounds, learned the art during the latter part of the last War and, practically without exception, their work was performed in Hand Centers established in the Zone of the Interior.

FIG. 9-A

A severely wounded hand. Index finger has been entirely avulsed; middle finger is badly shattered and functionless.

A great deal of the success in any program to rehabilitate the

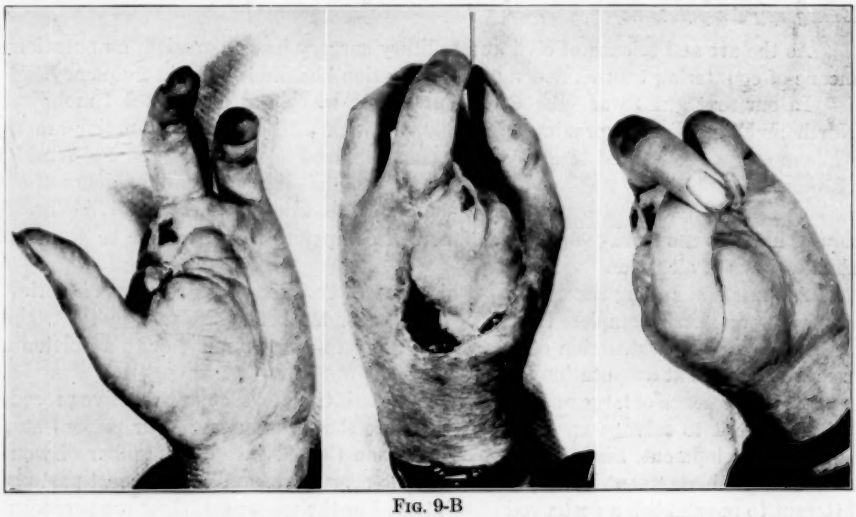

FIG. 9-B

The skin of the amputated middle finger was utilized to close skin defects on the dorsum of the hand. Three to four weeks later a useful three-finger hand was salvaged on this patient, at the 129th General Hospital.

wounded hand depends upon the early treatment of these casualties. This early treatment is instituted far from the General Hospital where reparative or reconstructive surgery is done. A meticulous cleaning of the hand is of paramount importance to minimize infection. The débridement should be careful, to conserve all possible tissue, especially viable skin. Whenever or wherever it is possible to hold the casualty for three to five days, immediate primary closure should be attempted by suture or split-thickness

graft. Toward the close of hostilities, these immediate closures were attempted in the European Theatre of Operations with extraordinarily good wound healing in the few that were observed.

One surgeon in an Evacuation Hospital reported verbally forty immediate primary closures of hand wounds without infection or other complication, and another reported approximately an equal number with but four or five infections.

Early in 1945, each of the Hospital Centers in the European Theatre of Operations had one General Hospital designated for the care of casualties involving the hand. The officer personnel in charge usually consisted of an orthopaedic or traumatic surgeon and a plastic surgeon, each invaluable to the success of this project.

The treatment of hand wounds was best exemplified by the report of Colonel Philip Foise, Chief of Surgical Service of the 129th General Hospital. Associated with Colonel Foise was Colonel Melvin White, a plastic surgeon. Hand wards, with immediately adjacent facilities for physical and occupational therapy, were set up. Each patient received on admission a copy of *The Hand Book* (Fig. 6). Sample pages from this stimulating book are shown, and also two posters used to indicate and suggest normal use of the hand (Figs. 7-A and 7-B). Gadgets to encourage the use of the hand are of *no value* unless their use is insisted upon. Occupational therapy will stimulate the wounded to use damaged hands and fingers (Figs. 8-A and 8-B). Often extensive surgical repair of the wounded hand is necessary (Figs. 9-A and 9-B).

The plan to salvage the wounded hand should instantly be put into motion in case of another emergency. Civilian practice of surgery offers numerous opportunities to duplicate and improve on these techniques.

Emergency Amputations

As the art and science of civil and military surgery has progressed, amputation as a means of countering trauma and resulting infection has diminished in frequency.

In our first great war—the Civil War—there was an estimated total mobilization, North and South, of approximately 3,000,000 with 52,000 surviving major amputees, while among an estimated total of 14,000,000 mobilized in all services during World War II, there are but 17,000 surviving major amputees. This represents an incidence of amputation in World War II of approximately one-tenth that in the American Civil War. These figures indicate the salvage of great numbers of compound fractures, due to gunshot and shell wounds of all types.

Amputation among these casualties is resorted to when an extremity is irretrievably damaged or a nearly complete traumatic amputation has been performed by the wounding missile. Complete destruction of the blood supply to an extremity, or to a portion of it, usually means that amputation is inevitable.

In the presence of large numbers of casualties, intricate vascular operative procedures, in an attempt to salvage an avascular part, are sheer madness, in our present stage of surgical development. Such treatment may mean the sacrifice of a number of wounded whose surgical treatment is delayed by the time-consuming, and for the most part useless, attempt to re-establish a destroyed circulation. For the most part, these are procedures to be done without pressure of time or backlog of wounded, and in a civilian hospital.

When the emergency amputation is performed on the contaminated and potentially infected battle casualty, or civilian casualty for that matter, an open circular amputation performed at the most distal point possible is probably safest and perhaps, in the end, most desirable.

Continuous skin traction usually results in closure of the skin over the stump. The definitive amputation can then be done with greater safety later at an elective site, the patient being allowed some choice in the decision.

There is, however, some basis for the claim that immediate closed-flap amputation at

an elective site would work equally well if *all damaged muscle and foreign bodies are removed.* Again we revert to the adequate wound excision. The healing power of these young men in superb physical condition is nothing short of miraculous. The great advantage of immediate elective amputation is that it prevents duplication of surgery. This should be considered in another national emergency.

Wounds Involving Joints

The major joints are frequently involved in wounds of the extremities, and their immediate early management was crystallized in a report by Colonel James E. Thompson, Major William C. Cassebaum, and Captain Charles F. Stewart of the Ninth Evacuation Hospital. Their experience was corroborated by Major Louis Goldstein of the Nineteenth General Hospital. While these authors wrote of the knee joint, the principles may and should be applied to all major joints.

If there is a penetrating or perforating wound of the joint, a wide surgical exposure of the joint should be done as early as possible through one or more incisions, as seem necessary, with careful excision of damaged soft tissue and cartilage and removal of all available foreign bodies. The joint cavity should be thoroughly irrigated with salt solution.

The synovial membrane and capsule should be closed by any possible means, with instillation of penicillin into the closed cavity. The skin and superficial tissues should be left open widely, while the extremity is adequately immobilized by a circular plaster-of-Paris splint with a trap cut over the wounded joint. After twenty-four to forty-eight hours, the joint may be aspirated or irrigated and the antibiotic again instilled.

Closure of the superficial wound by suture or skin graft should be accomplished three to five days after wounding.

Major Goldstein, in recording his experience with fifty wounds involving the knee joint at an overseas General Hospital—sixteen in United States Army personnel and thirty-four in prisoner-of-war personnel—proved the efficacy of the treatment just outlined. The German prisoners, due to the exigencies of battle situation, served to confirm our accepted techniques of treatment. The wounded prisoner of war always had a longer period of time elapse between the wounding and admission to a hospital,—that is, before the initial débridement could be done. All eight patients who arrived at the Hospital with the knee joint infected, and three of the four postoperative infections, were among the prisoner-of-war personnel. Among the sixteen United States Army personnel, there was only one trivial infection. The danger of delay in doing the initial débridement is obvious from these figures.

Major Goldstein performed delayed primary closure of the joint capsule in ten patients and delayed primary closure of the skin in thirty-two, with primary healing in twenty, before evacuation from the Hospital was necessary. Eight men were evacuated before healing could have ensued. There were three trivial infections.

These surgeons, in 1945, merely confirmed what Colonel Eugene Pool had advocated and practised in 1919.

The Transportation of the Wounded

The safe and comfortable transportation of the casualty with a compound fracture is of utmost importance to minimize further trauma and resulting additional shock. Emergency splints should be applied at the point of first aid. Following wound excision, the application of appropriate circular plaster-of-Paris splints, completely split to allow for swelling, will allow as much relief from pain as is possible during the journey back to the first fixed hospital.

There is on all sides talk of and preparation for World War III. I fervently hope this can and will be averted. The overpopulation of many areas and the bitter struggle for food and shelter suggest the possibility of war for survival at some future time. We cannot

afford to be complacent. We must be prepared. If such a future war comes, it will of course be total. Our civilian population will never again be spared. The civil surgeon and the military surgeon alike will be called upon to render emergency treatment to great numbers of casualties.

These battle casualties are distributed in almost direct proportion to the proportion of body surface which a part bears to the whole. The upper and lower extremities comprise 61 per cent. of the total body area. Of the wounded surviving to arrive at a hospital, over 70 per cent. have wounds involving the upper and lower extremities. This has been nearly constant in our three major wars. There is always an excess of survivors with extremity wounds, because these are less apt to be immediately fatal than are belly and chest wounds. Perhaps half of these extremity wounds result in injury to bones and joints. The care of battle casualties and civilian accidents puts a heavy burden on the bone and joint surgeon.

Our supply of trained bone and joint surgeons has been considerably increased since 1942. The diplomates of The American Board of Orthopaedic Surgery now number 1,286, plus probably another 200. In 1944 there were 820 diplomates in orthopaedic surgery, and 301 of these were in the Armed Services. The European Theatre, with 16,000 medical officers serving in the Army of the United States, had only sixty-three of these fully qualified orthopaedic surgeons. There was a total of 260 hospitals whose tables of organization called for one or more specialists with a rating of 3153,—orthopaedic surgeons. To meet the minimum needs of that Theatre, 446 orthopaedic surgeons could have been utilized if they had been available. To supplement the small supply of specialists, ninety-five partially trained orthopaedic surgeons and eighty-five general surgeons with full or partial training in fractures and traumatic surgery were utilized. These 240 medical officers carried the great bulk of the responsibility for the care of approximately 220,000 to 250,000 orthopaedic casualties among our troops, not to mention the large number in prisoners of war.

In time of great national emergency, there will never be a sufficient number of adequately trained bone and joint surgeons. Large numbers of undertrained surgeons will have to be utilized. These young medical officers can readily learn the relatively simple surgical techniques of routine traumatic surgery of the extremities. For the inexperienced surgeons, definite instructions and careful supervision are of the utmost importance to maintain high professional standards of treatment.

When you look carefully at the record, we actually did nothing new or startling in the emergency treatment of bone and joint casualties in World War II. We did, however, eventually accomplish very universal acceptance of sound surgical procedures which ensured a high standard of treatment for our wounded. The last word has not been written or spoken on military surgery. There will be many improvements in techniques, based on good surgical principles.

I urge you, who will carry on in case of another national emergency, to remember these surgical techniques of proved efficacy. You will have ample opportunity to apply many of them in caring for the appalling number of civilian accidents which our industrial and motor-driven age produces.

Let there be no repetition of what occurred between the two World Wars, when brilliant surgical procedures, facilitating the care of bone and joint casualties, gathered dust in libraries and were all but forgotten. Let us hold fast to and maintain these surgical concepts which these two Wars have taught us. Have a bold surgical approach planned for our wounded and see that it is carried out.

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(*Continued on page 279*)

CAUDA EQUINA TUMORS AS A CAUSE OF THE LOW-BACK SYNDROME *

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In the ten-year period from January 1939 through December 1948, forty-eight patients with tumors of the cauda equina or of the low spinal cord were operated upon in the Department of Neurosurgery of the Lahey Clinic. In this same ten-year period, 1,056 intervertebral-disc operations were performed at the Lahey Clinic. These tumors so frequently simulate disc lesions that it is believed an evaluation of this series of cases will be of interest to the orthopaedic surgeon as well as to the neurosurgeon. These tumors represent a small group, 48 of 1,104 cases, or 4.3 per cent. of the total. Since early, accurate differential diagnosis is of paramount importance for the prevention of permanent residual paralysis, this group, although small, is significant.

The difficulty of diagnosing these lesions has been recognized in the literature. Allen, reviewing the literature to 1930, noted that early recognition is of vital importance, because "it is only in the late and hopeless stages . . . that the classical clinical picture of a lesion of the cauda equina" is encountered. He found that one in ten spinal-cord tumors affects the cauda equina. Because of the number of nerve roots which may pass through or surround the tumor, these lesions are difficult to remove. Allen stated that only in the early cases is successful removal possible. He noted difficulties in localization, because the cauda equina roots are perpendicular and tumors involving the cauda equina at different levels may give approximately the same symptoms and physical signs. Also, because of the width of the sacral canal, tumors may grow within the canal for a long time without producing neurological signs.

Love reviewed twenty-six cases of spine tumor which, as he so aptly says, "masqueraded" as protruded intervertebral discs. Fifteen procedures were done at the Mayo Clinic for spinal neoplasms; during this same period 100 disc operations were performed. In eight of the fifteen tumor cases the typical disc syndrome was present.

Cohen and Kaplan, in a review of twenty-five cases, noted the great similarity of the clinical picture in the group with cauda equina tumor and in the intervertebral-disc cases. In addition, they noted that early diagnosis is not frequently made.

It is evident, therefore, that there is similarity in the clinical picture of tumors and discs. Thus the orthopaedic surgeon is in danger of treating a cauda equina tumor with heat and massage, belts and braces, postural training and exercise, or even by spine fusion and disc exploration. It is because of the constant possibility of error in the treatment of common low-back conditions that this review has been undertaken.

In the authors' series of forty-eight cases, the sexes were evenly distributed, there being twenty-four of each; the average age was forty-one years. The youngest patient was a girl of fourteen, in whom unilateral sciatica had developed four months before operation; at laminectomy she was found to have an ependymoma at the level of the third lumbar vertebra. The eldest patient was a woman of sixty-eight; she had had a radical mastectomy three years previously and metastasis had developed in the lumbar region.

* Read at the Annual Meeting of The American Orthopaedic Association, Colorado Springs, Colorado, May 19, 1949.

TABLE I

SYMPTOMS AND PHYSICAL SIGNS IN TUMOR CASES

Symptoms	No.	Signs	No.
Low-back pain	24	Absent or diminished ankle jerk	27
Unilateral sciatica	17	Sensory changes	24
Paraesthesia	15	Muscle atrophy	21
Weakness of legs	15	Positive straight-leg-raising test	19
Leg pain, other than sciatica	13	Muscle spasm in lumbar spine	11
Urinary and rectal symptoms, alone or in combination	10	Limited motion in lumbar spine	9
Night pain	5	Increased reflexes	7
Bilateral sciatica	3	Absent or diminished knee jerk	6
		Positive Babinski	4

SYMPTOMS AND SIGNS

Reviewing the classical signs of cauda equina lesions, Wechsler, in his textbook, noted that the cardinal symptom is pain, which may continue for a long time before neurological signs appear, so that the tentative diagnosis of hysteria is sometimes made. Pain in the lower extremities is characteristic of lesions of the cauda equina. The pain radiates to the back or the front of the thighs or to the perineum, or it may be sciatic in nature. Sometimes it is restricted to the "small of the back". Later symptoms are muscle weakness, flaccid paralysis, and impairment of all forms of sensation. Wechsler stated that patients with low-spine lesions have relatively late involvement of the bladder and

FIG. 1

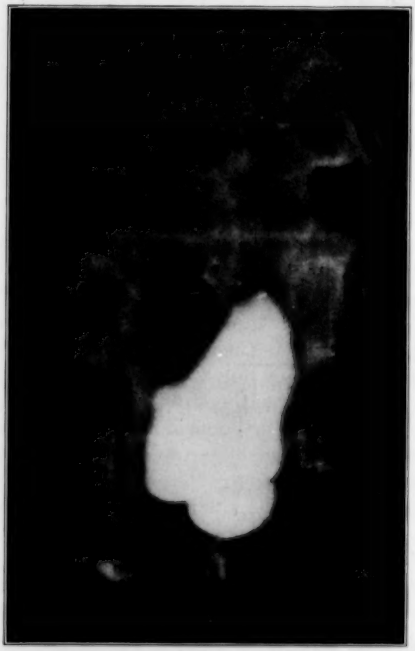

FIG. 2

Fig. 1: Case 35. Pantopaque myelogram shows definite block with cap formation at second lumbar vertebra, produced by ependymoma.

Fig. 2: Case 8. Pantopaque myelogram shows block at the first lumbar vertebra, caused by glioma.

of the rectum, as well as late saddle anaesthesia. If the lesions are higher —that is, in the conus medullaris— the bladder and rectal changes are early and severe. Saddle anaesthesia is present; ankle jerks are absent; the power of erection and ejaculation in the male is impaired; and there may be loss of pain and temperature sense. In lesions of the epiconus, paralysis of the feet is an early sign.

Thus, when the picture has become well established, the disease may have progressed to the late and hopeless stage.

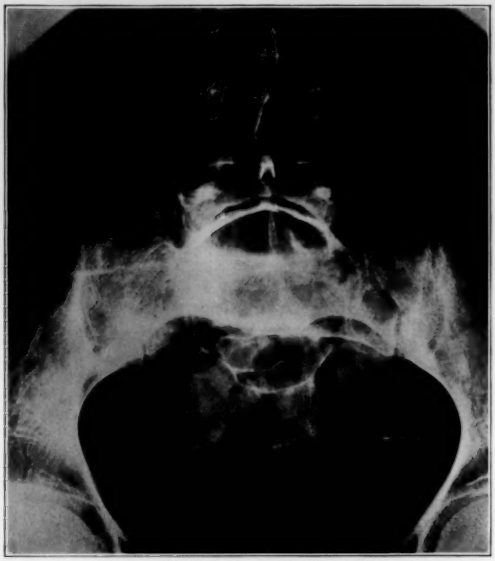

FIG. 3

Case 37. Lumbosacral roentgenogram shows an oval defect in the sacrum, due to expansile tumor. The microscopic diagnosis was cyst with collagenous walls.

In spite of the many difficulties connected with establishing an early diagnosis, certain symptoms and signs are more suggestive of tumor than of disc lesion. In the authors' patients, an insidious onset of pain without a history of trauma, and an unremitting, progressive course definitely suggested tumor. The initial symptom of numbness in both legs is more frequently associated with tumor, as is early weakness of the lower extremities, especially when this is bilateral. Bladder and rectal disturbances, when present, usually come so late that they are not helpful in the early differentiation of these conditions, and involvement of the sphincters is more often associated with tumor than with a disc lesion; but a large disc herniation appearing rapidly after trauma may immediately produce bladder and rectal changes. Patients with tumor are not so likely to have remissions as are patients with disc lesions. Pain that is constant, unrelieved by recumbency, and severe enough to prevent sleep at night is more commonly associated with tumor. The patient with a ruptured intervertebral disc usually has recurrent attacks of sciatica, and he is usually able to obtain relief from pain while in the recumbent position.

The duration of symptoms from onset to date of operation varied in this series from two months in a patient with a widely disseminated leiomyosarcoma to eight years in a woman of fifty-six years with a neurilemmoma. The average duration of symptoms prior to operation was twenty-five months. The incidence of the various symptoms, irrespective of when they appeared, is noted in Table I, as are also the physical signs.

The most common presenting symptom was low-back pain. The next most frequent symptom was unilateral sciatica, and the third was numbness of the legs. In addition, six patients had the primary complaint of vague leg pain and two had the initial complaint of weakness of the legs. Usually rectal and urinary symptoms appeared late.

Six patients, or 12 per cent., had no pain at any time. The primary complaint was numbness of the lower extremities. Spurling and Mayfield, in a review of forty-two neoplasms of the spinal cord, found that 26 per cent. of the patients had no pain.

The most common single physical sign in this series of tumors (Table I) was absence or diminution of ankle jerks, which occurred in twenty-seven cases. Next were objective sensory changes. Since many of these physical signs are commonly found in intervertebral-disc lesions, it may be impossible to distinguish between tumors and disc lesions on the basis of the symptoms and physical signs alone. In fact, tumors may become very

extensive, especially the slow-growing ones, with little change in the lower extremities. This is illustrated by the four following cases, in which the neurological examination was completely negative.

CASE 5. A fourteen-year-old girl, who had an ependymoma at the level of the third lumbar vertebra, had no physical signs other than lumbar muscle spasm and a positive straight-leg-raising test on both sides.

CASE 1. A man, fifty-eight years old, who had had low-back pain and sciatica for two years, was found to have a neurilemmoma at the level of the fourth lumbar vertebra. He had no positive physical signs other than a list and limitation of motion of the lumbar spine.

CASE 23. A woman, forty-one years old, who had had low-back pain, radiating into the thigh, for a year and a half, and progressive leg weakness for three months, was found to have a neurofibroma at the level of the third lumbar vertebra. The neurological examination was entirely negative.

CASE 37. A man, forty-six years old, had had a history of sacral pain for nine months with completely negative neurological findings. Roentgenographic examination showed that he had a defect in the sacrum, due to an expansile tumor. At operation a cystic lesion with collagenous walls was found.

Allen stated that there are no sensory changes in 23 per cent. of cases.

Horrax, in presenting a series of 141

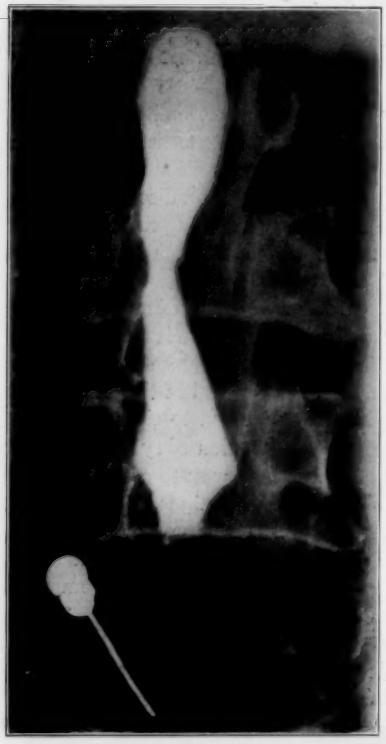

FIG. 4

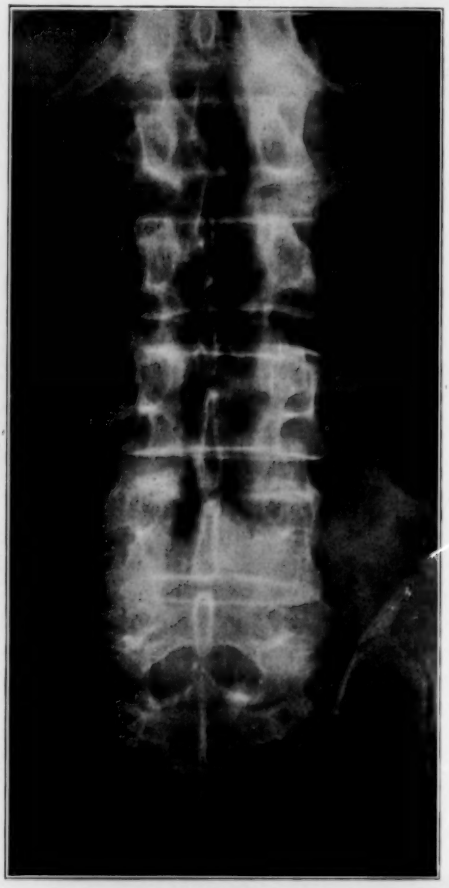

FIG. 5

Fig. 4: Case 32. Pantopaque myelogram. Filling defect is seen opposite body and disc of the third lumbar vertebra. The diagnosis was metastatic carcinoma from the right upper-lobe bronchus.

Fig. 5: Case 1. Oxygen myelogram with complete block at level of the fourth lumbar vertebra. The diagnosis was neurilemmoma.

spinal-cord tumors, noted that the lesions in the lumbar region may simulate those produced by a ruptured intervertebral disc. He stated that these patients had often been treated for a long time before the diagnosis was established, and emphasized the importance of careful neurological and lumbar-puncture studies.

Several cases in the present series illustrate serious errors in diagnosis, as indicated by the following brief case reports.

CASE 9. A woman, thirty-two years old, had an intervertebral disc removed nine months after the onset of sciatic pain. The pain continued to involve both legs. Three years later, when bladder and rectal disturbances began, roentgenograms demonstrated widening of the lumbar canal from the fourth lumbar vertebra to the first sacral vertebra, and an extensive neurilemmoma was removed.

CASE 10. A man, fifty-two years old, had had lumbosacral backache for five years; the condition was not relieved by a spine fusion, done elsewhere, three years before. The sciatica on the left persisted and later bladder and rectal disturbances appeared. An ependymal cyst was removed.

CASE 11. A woman, thirty-six years old, had had low-back pain and sciatica on the left side for seven years. Coccygectomy, performed one year after the onset of symptoms, did not afford relief. Three years

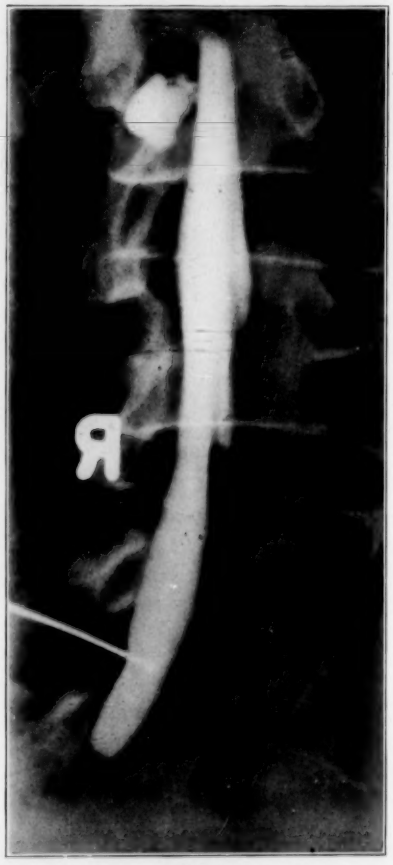

FIG. 6

FIG. 7

Fig. 6: Case 34. Pantopaque myelogram demonstrates extravasation into communicating cyst at the level of the third lumbar vertebra.

Fig. 7: Case 17. Pantopaque myelogram shows block at first lumbar vertebra with cap formation. The diagnosis was neurilemmoma.

later bladder and bowel disturbances developed, and at this time roentgenograms revealed changes suggestive of a chordoma; this finding was later verified by laminectomy. Complete removal was impossible because of the size of the tumor.

ROENTGENOGRAPHIC STUDIES

In this series, twenty-seven patients had oxygen myelograms; eight had pantopaque myelograms; and in seven lipiodol was used. In six additional cases, myelograms were not done because the original lumbosacral roentgenograms were diagnostic.

In the authors' earliest cases, lipiodol was used; this was later supplanted by oxygen to prevent any possible ill effects from the use of lipiodol. More recently, pantopaque has been found to be highly satisfactory in most instances.

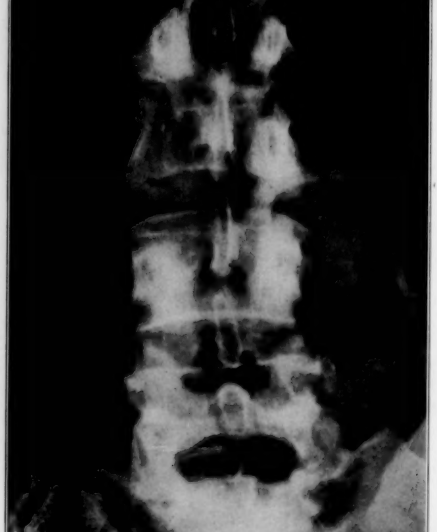

FIG. 8

FIG. 9

Fig. 8: Case 21. Oxygen myelogram with narrowing of column at third lumbar vertebra and destruction of facet at third lumbar vertebra on left. The diagnosis was metastatic thyroid carcinoma.

Fig. 9: Case 18. Roentgenographic changes are consistent with pressure on the pedicles of the first to third lumbar vertebrae. Oxygen myelogram showed block at first lumbar level. The diagnosis was neurinoma.

TABLE II

PATHOLOGIST'S DIAGNOSIS OF TUMORS FOUND AT OPERATION

Malignant	No.	Benign	No.
Leiomyosarcoma	1	Neurilemmoma	16
Lymphoma	1	Ependymoma	9
Malignant tumor, unclassified	1	Neurofibroma	4
Myxofibrosarcoma	1	Meningioma	2
Metastatic carcinoma		Fibrous cyst	2
Thyroid	1	Ependymal cyst	1
Bronchus	1	Chordoma	1
Prostate	2	Lipoma	1
Breast	1	Fibrosis	1
Neurogenic fibrosarcoma	1	Chronic inflammation	1
Total	10		38

Complete subarachnoid blocks were present in nineteen instances and xanthochromic fluid was noted in seven cases.

The authors feel that the single most important factor in the diagnosis of cauda equina lesions is the myelogram. In many cases, the history and physical findings are equivocal, but the use of contrast media establishes the differential diagnosis between a tumor and a disc lesion. The myelogram should be utilized as a routine in all cases of suspected disc lesion, in order that the patient can be given the best and most complete investigation before surgical interference is instituted.

TOTAL PROTEIN

Estimation of the total protein is also of great value in giving weight to the myelographic findings. The values for total protein in this series varied from 14 to 610 milligrams per 100 cubic centimeters, the average being 140 milligrams:

Milligrams per 100 Cubic Centimeters	*Number of Cases*
Over 200	9
100 to 200	9
45 to 100	9
Below 45	11

In 70 per cent. of the patients the total protein was definitely increased, many of the readings being markedly elevated. The protein level was of great aid in diagnosis, since a markedly high protein is an unusual finding in association with a disc lesion unless complete block is present. However, tumors cannot always be relied upon to produce protein elevation, because normal findings were present in 30 per cent. of the total.

PATHOLOGICAL FINDINGS

The classification of these tumors has been well described by Kernohan and his associates and by Grinker.

In the present series ten patients, or approximately one-fifth, were found at operation to have malignant tumors (Table II). The pathological findings in the remaining thirty-eight cases showed benign tumors. Neurilemmoma was by far the most frequent (Table II). This was present in sixteen cases, or 42 per cent. of those with benign lesions. Ependymoma was present in nine instances, comprising 24 per cent. of the benign lesions. A case of fibrosis is included, and also a case of pressure due to the previous use of lipiodol. Thus the tumors were of wide variety. A preoperative diagnosis of the type of tumor is well-nigh impossible.

SUMMARY

This review was undertaken to stress the ever-present possibility of serious error in the diagnosis of low-back conditions, and to emphasize the difficulties in the diagnosis of cauda equina lesions.

Forty-eight cases of tumor of the cauda equina or low spinal cord are reported in which operation was performed at the Lahey Clinic between 1939 and 1948. In this same time interval, 1,056 intervertebral-disc operations were performed. The tumors represent 4.3 per cent. of the entire group. The patients with tumors ranged in age from fourteen to sixty-eight years; the numbers of males and females were equal.

Early diagnosis is of paramount importance in the tumor cases. There is great similarity in the clinical picture of tumors of the cauda equina and disc lesions.

Insidious onset of pain with an unremitting course definitely suggests tumor. Numbness and weakness of the legs is more often associated with tumor. The duration of symptoms varies from two months to eight years. The most common first complaint was low-back pain, but 12 per cent. of the patients had no pain whatsoever.

The most common physical sign in the tumor cases was an absent or diminished ankle jerk, but this finding is common in disc lesions, also. Tumor lesions cannot usually be differentiated from disc lesions by physical signs. In 8 per cent. of the tumor cases, neurological signs were not present.

The myelogram is the most significant and valuable aid in the differential diagnosis. The use of pantopaque, removed at the time of fluoroscopy, is preferred at the present time.

Estimations of total protein ranged from 14 to 610 milligrams per 100 cubic centimeters, the average being 140. A protein determination of over 100 definitely suggests tumor and is a valuable diagnostic aid. However, in 30 per cent. of the patients who had tumors, the total protein was not elevated.

In this series, 20 per cent. of the tumors were malignant. Of the benign tumors, neurilemmoma was by far the most common, with ependymoma second.

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AN EVALUATION OF MYELOGRAPHY IN THE DIAGNOSIS OF INTERVERTEBRAL-DISC LESIONS IN THE LOW BACK *

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In the past, following the precepts of Walter Dandy, the authors have operated upon patients with disc lesions in the lumbosacral spine without subjecting the individuals to myelography. The diagnosis and the approximate location of the disc lesions were determined from the history, physical examination, and roentgenograms.

Beginning in September 1946, myelograms were made in a series of patients in the hope that this change would improve our results in the treatment of patients with low-back pain. Consequently, during the past two and one-half years, preoperative myelograms have been obtained in the majority of patients referred to the hospital for exploration of the lumbosacral canal in an effort to relieve pain in the low back, with or without sciatica. This paper reports the results of the authors' attempts to correlate the findings in the myelograms with the operative findings in 206 cases.

The contrast media which have been injected into the subarachnoid cavity for the purpose of studying roentgenographically the form of the lumbosacral canal are air, lipiodol, thorotrast, and pantopaque. Air has the advantage that it is absorbed, but it affords relatively weak contrast and interpretation of the findings is difficult. Lipiodol affords excellent contrast, but is quite viscous and difficult to remove. It is also mildly irritating, and febrile reactions occur frequently after its use. It is not absorbed and, if it it is left in the subarachnoid space, it may become dispersed and encysted and possibly cause headaches. Thorotrast is radio-active, and for this reason might be dangerous if left in the subarachnoid space.

Pantopaque (ethyl iodophenylundecylate) affords excellent contrast. It is heavier than spinal fluid and not miscible with it. It flows readily in the spinal canal, does not easily separate into globules, and is not difficult to remove. If not removed, it is slowly absorbed from the subarachnoid cavity, the rate being about 1 cubic centimeter a year. It was first suggested for myelography by Strain, Plati, and Warren.

The authors have used pantopaque in taking the myelograms on 253 patients; in 206 of these, the lumbosacral canal was explored surgically.

TECHNIQUE OF MYELOGRAPHY

The patient is given preliminary medication of from one-sixth to one-fourth grain (0.010 to 0.015 gram) of morphine hypodermically, and 3 grains (0.2 gram) of nembutal from thirty to sixty minutes before the procedure. This is done partly to allay apprehension, but mainly because removal of the pantopaque may be painful.

The skin is painted with a skin antiseptic; a point over the third lumbar interspace and the interspinous ligament between the third and fourth lumbar vertebrae are infiltrated with 1 per cent. novocain. With the patient in the sitting position, a lumbar puncture is performed, an attempt being made to insert the needle in the mid-line. The patient is then eased onto his side, 10 cubic centimeters of spinal fluid is removed, and the pantopaque is injected slowly and evenly. It is well to stop several times and withdraw the plunger a little, in order to be sure that the point of the needle is still in the subarachnoid cavity, as extradural injection may obscure visualization of the intradural space even though a second injection is done. In most instances, 3.3 cubic centimeters of pan-

* Read at the Annual Meeting of The American Orthopaedic Association, Colorado Springs, Colorado, May 19, 1949.

topaque (the contents of one ampule) was injected. In twenty-three instances, larger amounts (from 6.6 to 17 cubic centimeters) were used.

The stylet is then inserted in the needle which has been left in place, the patient is laid prone on a tilting fluoroscopic table, and the column of pantopaque is studied with the patient in various positions from prone to erect and obliquely and laterally, as well as in the straight anteroposterior direction. The course of the pantopaque is watched closely through the fluoroscopic screen, as it flows up and down in the dural sac while the patient is tilted down or up, and spot films are taken whenever this seems desirable. The outline of the dural sac and the root sleeves are studied, and any obstruction to free movement of the pantopaque is noted. In some instances, the patients are also examined in the erect position with the spine in hyperextension.

The head of the column is watched carefully at each disc level as it begins to flow over the disc, because it may then reveal a small defect which is hidden when the full column flows over the disc. Large defects can often be seen at a glance, but small ones may be hard to identify. The same is true of abnormalities in the filling of root sleeves.

After the fluoroscopic and roentgenographic studies have been completed, the patient is turned onto his abdomen, the pantopaque is pooled around the tip of the needle under the fluoroscope, and as much of the material as possible is removed. It is usually possible to remove almost all of the radio-opaque medium.

Interpretation

In studying the spot films, a search is made for the following types of defects:

1. A lateral indentation in the outline of the dural sac. This may be large or small, and indicates a lateral protrusion of a disc. It is not a reliable index of the size of the disc lesion, however, because quite large protrusions may cause only small indentations in the outline of the dural sac.

2. An hourglass or stricture type of defect which suggests bilateral protrusion of a single disc. This type of defect really denotes a mid-line protrusion. Begg, Falconer, and McGeorge explained this anomaly by pointing out that the mid-line protrusion crowds the intradural nerve roots at that level to each side, leaving a thin, narrow channel in the mid-line over the dome of the protrusion, and that, as the patient is tilted, the medium flows up or down in this channel.

3. Striation of the column of medium near the margins of the sac. Begg, Falconer, and McGeorge described this appearance and attributed it to oedematous nerve roots in the dural sac. The authors have encountered this appearance in a considerable number of the myelograms of patients with severe symptoms.

4. Asymmetry or failure of the axillary root sleeve to fill with the opaque medium on one side, although it fills and presents a normal appearance on the opposite side. This occurs especially at the lumbosacral level, and may be the only evidence in the films of a very large disc protrusion at this level. Consequently, the outlines of the root sleeves should be studied carefully.

5. Anterior indentations in the column, visible in the lateral view. These anterior indentations must be interpreted with care as, in many normal spines, there is a slight posterior bulge of the lumbar discs; this may be increased to a small extent when the lumbar spine is hyperextended by having the patient elevate his head and shoulders. Begg, Falconer, and McGeorge considered posterior protrusions of two millimeters to be within normal limits, and noted that this amount was not increased appreciably when the patient stood erect with a load of seventy pounds on his head. Occasionally, a soft disc or one producing symptoms intermittently may be revealed by the hyperextension manoeuvre. A large lateral defect may not show in the lateral view, but wide mid-line bulging discs may cause anterior defects, higher than the normal range of two millimeters.

6. A block type of lesion with more or less complete obstruction of the canal.

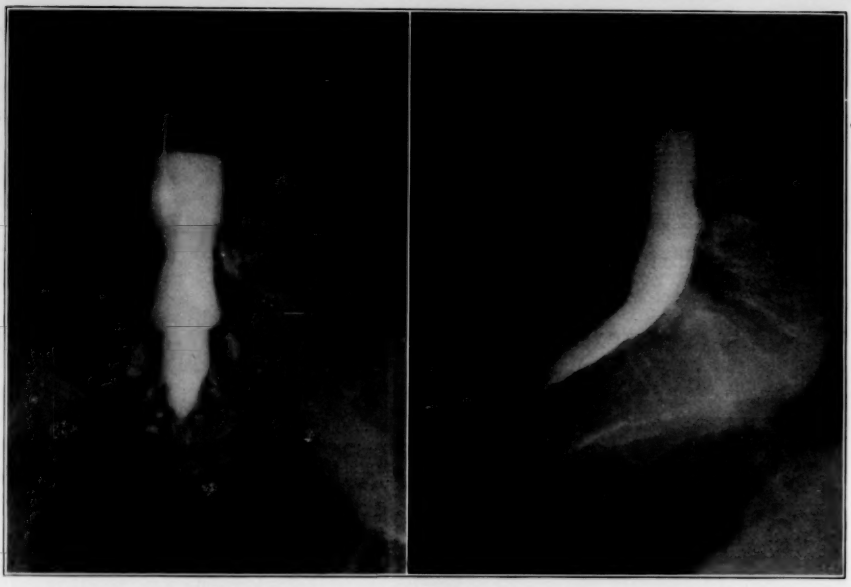

FIG. 1

After injection of 10 cubic centimeters of pantopaque, a defect was found at the fourth interspace on the left, with obliteration of the root sleeve. This finding was confirmed at operation. The clinical result was good.

FIG. 2

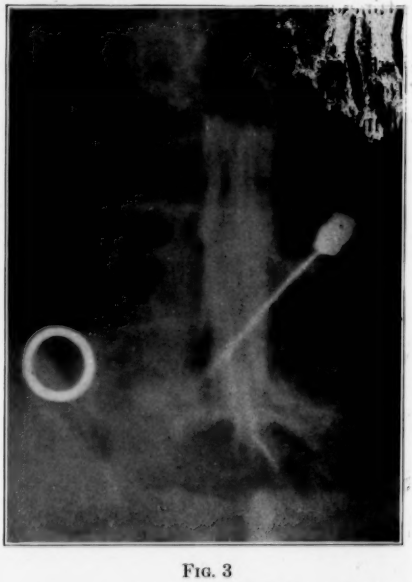

FIG. 3

Fig. 2: An hourglass defect at the fourth interspace was seen after injection of 6 cubic centimeters of pantopaque. A large mid-line defect was diagnosed, and this was confirmed at operation. There was no discrepancy between the myelographic and operative findings. The clinical result was good.

Fig. 3: A block type of defect appeared at the fifth interspace with striation, indicating oedema of the nerve roots, after injection of 6 cubic centimeters of pantopaque. A completely extruded disc was removed at the fifth space. No discrepancy was noted between myelographic and operative findings. The clinical result was good.

As noted earlier, in twenty-three instances the authors injected larger amounts (6.6 to 17 cubic centimeters) of pantopaque into the spinal canal and studied the outline of the column of opaque medium in various positions, in order to determine whether or not a larger amount of pantopaque would make the procedure more accurate. The larger amount of medium enabled us to see more discs at one time and thus the number of spot films was lessened, but this saving was offset by the cost of the pantopaque*. Also, the large amount of pantopaque tended to make the diagnosis less accurate, as it was less mobile than the small column and it is important to observe the head of the column as it flows over the abnormal disc. Likewise, the striations caused by oedematous nerve roots are seen more clearly when the smaller amount of opaque material is used.

In addition, the use of larger amounts of pantopaque was followed by a larger percentage of postmyelographic reactions (26 per cent. as compared with 4.3 per cent. in the patients in whom only 3.3 cubic centimeters of fluid was used). These reactions took the form of headaches, stiffness of the neck, low-grade fever (two cases), meningismus (two cases), ileus (one case), and increased cell count in the only two cases in which the spinal fluid was examined after the spinogram. In some cases, these reactions were so severe that the operation was postponed for a few days.

RESULTS

In this series of 253 myelograms, defects indicating lesions of an intervertebral disc were noted in 201 cases. In the other fifty-two cases, the myelograms were interpreted as revealing nothing abnormal. In 206 of these patients, the lumbosacral canal was explored.

In 167 of these patients, the preoperative myelograms were interpreted as showing

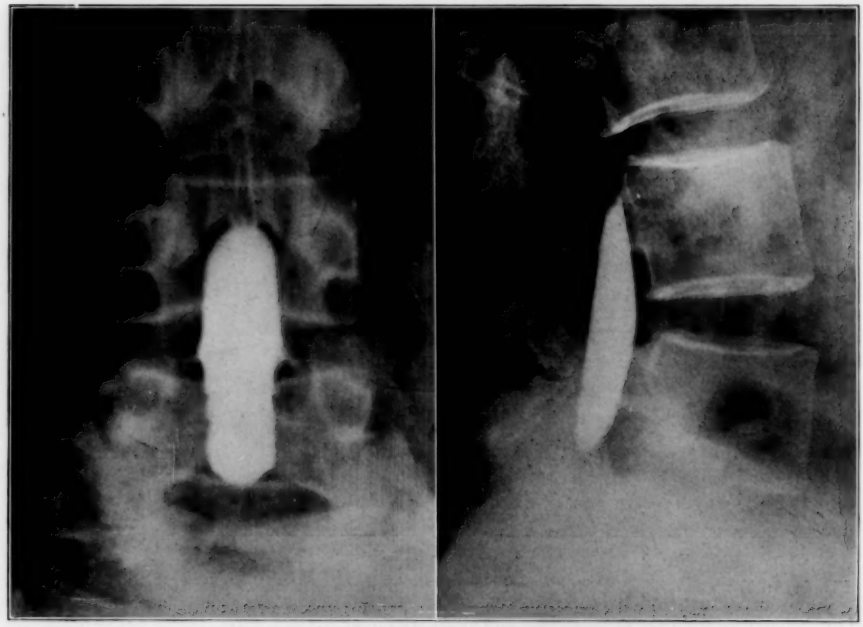

FIG. 4

Myelographic findings were negative. At operation, a protruded disc was found on the left side at the fourth lumbar level. The clinical result was good. This was a major myelographic discrepancy.

* $2.75 per ampule of 3.3 cubic centimeters.

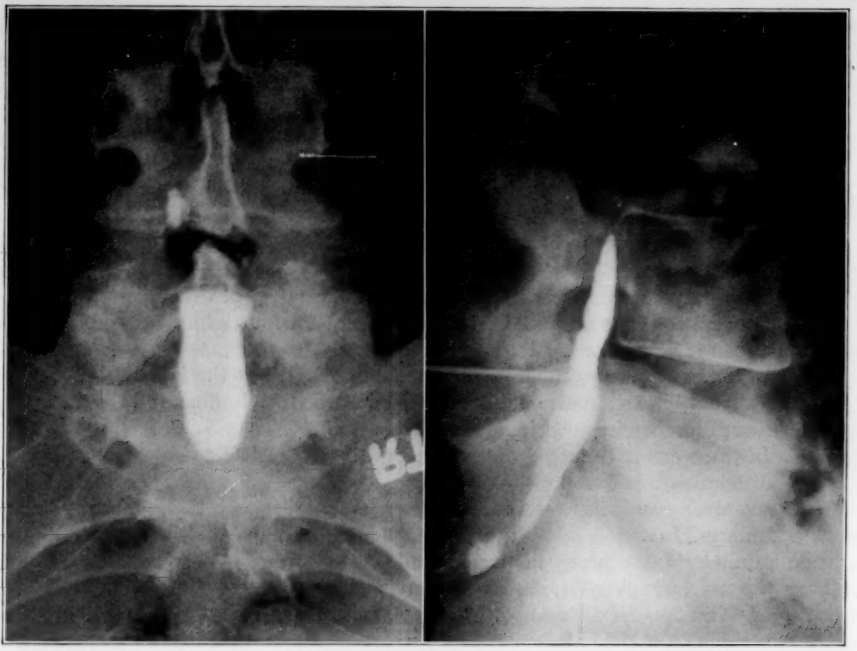

FIG. 5

Myelographic findings indicated a protruded disc at the fourth lumbar mid-line. At operation, a bulging disc was found at the fifth. The fourth disc was normal. The clinical result was good. This was a major discrepancy.

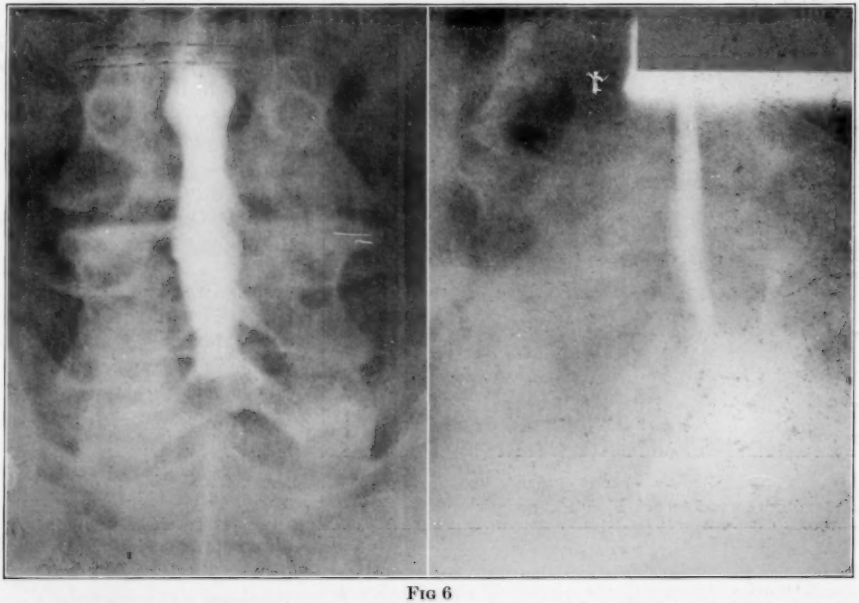

FIG 6

Myelographic examination was negative. A large extruded disc from the fourth space was removed from the posterior surface of the body of the fifth lumbar vertebra. The clinical result was good.

intervertebral-disc lesions (including one intradural neurofibroma); in thirty-nine, the myelograms were considered to be within normal limits. Comparison of the myelograms with the operative findings in these 206 cases reveals the following data:

1. In 149 cases, the myelographic findings were confirmed at operation.
   - A. The myelograms were positive in 137 cases, and corresponding lesions were found at operation.
   - B. In twelve cases, the myelograms were negative and no abnormal discs were found at operation.
2. In forty cases, there were major discrepancies between the myelographic and the operative findings.
   - A. In twenty-seven cases with negative myelograms, protruded discs were found at operation (one at the third lumbar, nine at the fourth lumbar, and seventeen at the fifth lumbar level).
   - B. In ten cases, the myelogram indicated a disc lesion at the fourth lumbar level, at operation an abnormal disc was found at the fifth lumbar and the disc at the fourth lumbar was considered normal.
   - C. In three cases, the myelogram was positive for a defect, but at operation no disc lesion was found.
3. In seventeen cases, there were minor discrepancies between the myelographic and operative findings. In these cases, the myelogram indicated a mid-line defect, but at operation a unilateral disc protrusion was found.

Thus the myelographic findings were confirmed at operation in 149 cases or 72.3 per cent., and discrepancies were noted in fifty-seven cases (forty major and seventeen minor discrepancies) or 27.7 per cent.

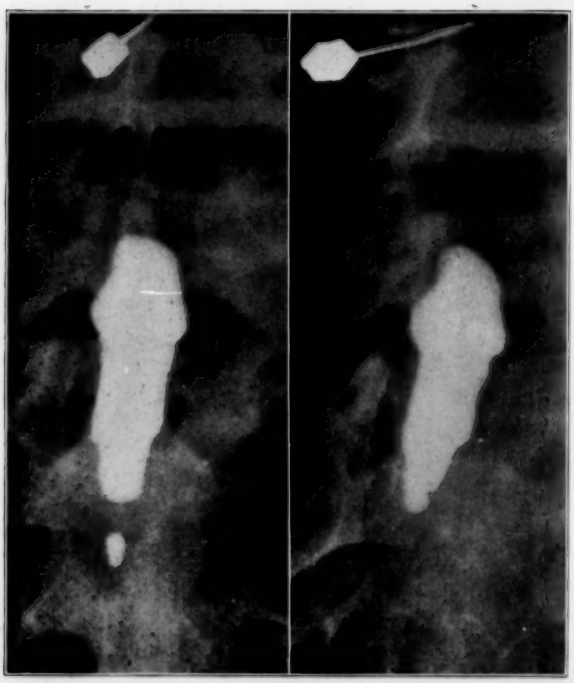

FIG. 7

The myelographic diagnosis was extrusion of the disc at the fourth lumbar interspace. At operation, a completely extruded disc was found at the fifth interspace. The clinical result was good. This was a major discrepancy.

The most important of the major discrepancies are: (1) those in which a protruded disc is placed too far laterally to affect the column of pantopaque, (2) those at the fifth interspace, where there is an unusually short cul-de-sac, and (3) those associated with an unusual amount of space anterior to the dura in the angle between the fifth lumbar vertebra and the sacrum. In some instances, a large disc protrusion may occupy this space and not be visible in the myelograms.

The authors are not able to explain some of the discrepancies. This is especially true of the false positives, in which the myelogram indicated a protruding disc at a given level and no protrusion of the disc was found when this level was explored.

Horwitz stated, largely

on the basis of cadaver studies, that defects in the myelograms may be produced by disc rupture, disc degeneration, hypertrophy (osteophytes) of the vertebral bodies, or hypertrophy of the apophyseal joints. To these causes might be added adhesions, either inside or outside of the dura, and neoplasms. The authors have encountered four neoplasms in this series,—one intradural neurofibroma which was revealed and diagnosed preoperatively by the myelogram, and three extradural neurofibromata which were not shown in the myelogram. All were removed at operation.

The minor discrepancies, in which a disc lesion was found at the level indicated, but the lesion was of a type different from that expected, are relatively unimportant, because they did not affect the treatment of the patient or the operative procedure.

In the authors' experience, multiple disc lesions are not seen frequently in the myelograms. Only 32 of 206 (15.5 per cent.) were noted in the entire group, and this observation has been confirmed at the operating table. At one time the authors followed the practice of Dandy and, after having removed the protruding disc, carefully examined the adjacent discs. If they seemed unusually soft or thin, or if they were bulging slightly, these also were removed. If one follows this procedure and has a low threshold of evaluating what is abnormal, then multiple discs are often found. However, before beginning this series of observations, the authors had adopted a more conservative attitude and had ceased removing discs unless there was definite evidence that the disc was abnormal and a probability that it was causing symptoms. The authors now believe that removal of a disc which is not causing symptoms may do more harm than good.

The results in this study have been compared with those of other workers who have attempted to correlate their operative findings with those observed in the myelogram. Camp reported 203 cases in which myelograms had been made and the patients were then

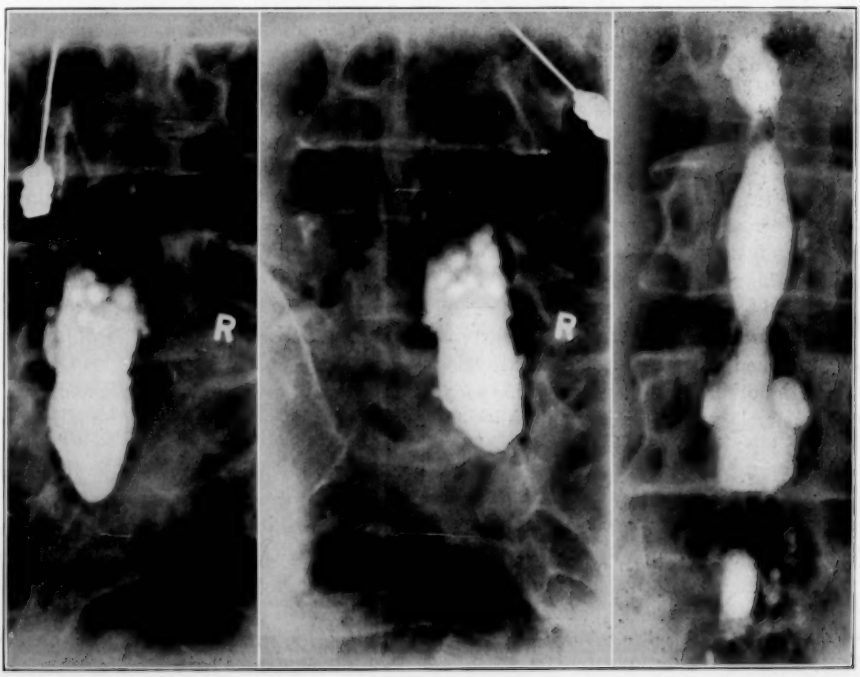

FIG. 8

The myelographic diagnosis was mid-line protrusion at the third space. At operation, extrusion of the fifth disc was found, far laterally on the right. The third disc was normal. This was a major discrepancy in a recent case.

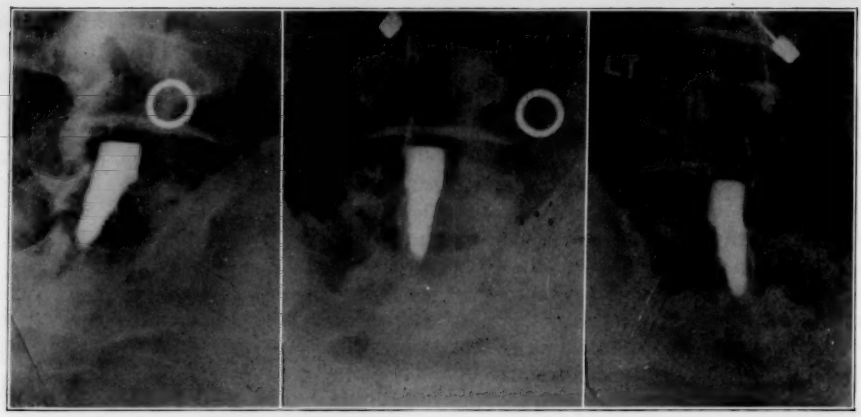

FIG. 9

Although the myelogram was negative, at operation an extruded disc was found at the fifth lumbar interspace on the right. The dural sac was short. This was a major discrepancy. The patient's symptoms were relieved.

operated upon for protrusion of an intervertebral disc. In his series, the myelographic and operative findings agreed in 92.3 per cent. of the cases. Soule, Gross, and Irving in 129 myelograms, followed by seventy-seven operations, found eight discrepancies in the cases with positive myelograms and four in those with negative ones, or a myelographic accuracy of 81.5 per cent. Begg, Falconer, and McGeorge obtained eighty-six satisfactory myelograms in 95 of 100 operative cases, with an accuracy in the myelogram of 85 per cent. Scoville, Moretz, and Hankins, in a series of 196 cases in which operation had been preceded by myelograms, reported that the myelographic finding was confirmed at operation in only 131 cases or 67 per cent. They considered that one-half of these were major errors and the other half were minor discrepancies.

In the series of 253 cases with 206 operations reported here, the myelographic diagnosis was accurate in only 72.3 per cent. The discrepancy between these findings and those of some other observers is not entirely due to our relative inability to perform and interpret myelograms or to properly explore the lumbosacral canal surgically, but is probably due to the method of using the myelogram. The authors do not employ this procedure until the diagnosis has been made and the decision has been reached that the patient will not respond to conservative treatment. Then the myelogram is used as an aid in localizing the lesion; however, if operation is clearly indicated by the history and physical findings, it is performed in spite of a negative myelogram.

On the other hand, in a borderline case, and especially in a patient who is neurotic, a negative myelogram often is the deciding factor against operation. Most of the failures of operation have been in this type of patient.

ANALYSIS OF FINDINGS

The most significant errors occurred in the twenty-seven patients with negative myelograms and positive operative findings, who were operated upon because of the severity of their symptoms. Had we assumed a high diagnostic accuracy of the myelograms, most of these patients might not have been operated upon.

Of the ten major discrepancies in which the myelogram was inaccurate as to the level of the lesion, it is possible that designation of the interspace by the surgeon at operation was faulty. However, we believe that this was not the case. It is the authors' custom to identify the posterior surface of the sacrum early in the operation and to use this for orientation. The disc which is believed to be causing the difficulty is then examined and,

if this is found to be normal, the adjacent discs are examined. Sometimes a complete hemilaminectomy of the fifth and fourth lumbar vertebrae is performed, in order to satisfactorily complete exploration of this area. A disc is not removed unless it is found to be abnormal and is believed to be causing symptoms. Some of the patients in this series have had relief from their symptoms following the decompression procedure only.

In five cases, fusion was carried out without exploration of the spinal canal. One patient had back pain associated with spina bifida, and a hemivertebra. Myelograms showed no disc defect, but did show a bizarre pattern caused by the spina bifida.

In another patient who had had back pain and sciatic pain for twelve years after a mine injury, a peculiar pattern was seen in the myelogram, amounting to a partial stricture of the subarachnoid space. The lower portion of his spine was fused without exploration of the canal. He was relieved of pain for several months, but after one year the same symptoms recurred. Another patient showed an elevated axillary sheath of the first sacral nerve root, in addition to spondylolisthesis. Spine fusion was recently performed, without exploration of the canal. The other two patients had old collapsed sclerotic discs.

In the remaining forty-two cases, operation was not performed. In most of these cases, there was no doubt as to the cause of the low-back pain or the sciatica; myelograms were performed to complete their study. In the group, disc defects were noted in twenty-two cases. One patient was felt to be too poor a surgical risk, several decided not to have operations, and in other cases, surgery was decided against because of compensation factors, or because of poor mental outlook. In twenty cases, the myelograms were normal and, because of the borderline signs and symptoms, surgery was not advised. One of these patients subsequently had prostatic carcinoma, metastatic to the spine, and died.

In view of these findings, the authors shall continue to use myelography in the study of patients with low-back pain, with or without sciatica, but probably only in selected cases. The procedure adds to the cost of the patient's illness *; it may add to the period of hospitalization; it may be followed by unpleasant reactions; and it may give false information. On the other hand, it is a valuable, but not infallible, adjunct in the diagnosis of disc lesions; it is of considerable value as evidence in compensation and medicolegal cases; and it may be of considerable help to the surgeon in deciding whether or not he should operate in certain borderline cases.

SUMMARY AND CONCLUSIONS

1. Myelograms have been performed in 253 cases of low-back pain with or without sciatica; 206 patients were operated upon and the spinal canal was explored.

2. One hundred and thirty-seven positive and twelve negative myelograms were confirmed at operation.

3. Minor discrepancies were noted in seventeen cases or 8.3 per cent., and major discrepancies in forty cases or 19.4 per cent.

4. In 230 cases, 3.3 cubic centimeters of pantopaque was used with ten reactions. In twenty-three cases, larger amounts (6.6 to 17 cubic centimeters) were used with six reactions or 26 per cent. Use of more than 3.3 cubic centimeters was found to be of doubtful value and, even though most of the medium can be removed, the technique is not to be recommended because of the higher incidence of reactions.

5. The presence of an intervertebral-disc lesion and its probable location should be determined from the history and physical examination. If operative treatment is decided upon, the patient may or may not be subjected to a preoperative myelogram.

6. Such a myelogram is a valuable aid in diagnosis and may be a decisive factor in borderline cases. In cases in which operation is clearly indicated, a negative myelogram should be ignored.

* The roentgenograms alone cost $25.00 to $50.00 or more. No charge has been made for services.

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DISCUSSION

Dr. Joseph S. Barr, Boston, Massachusetts: The two papers we have just heard, although on apparently unrelated topics, really complement each other, as perhaps I can point out later.

Albert Key and Dr. Ford have given us a careful analysis of the diagnostic accuracy of pantopaque. There is no question in my mind, or in theirs, that pantopaque is the best of the available contrast media for myelography. In skillful hands the test is relatively painless, and we have no authenticated case of serious ill effects from its use in over five hundred tests done at the Massachusetts General Hospital.

I would like to comment on two points in the technique of myelography:

There is danger of the needle slipping out of the dural canal or of its injuring nerve roots, if the puncture is done while the patient is in the sitting position and the patient is then moved to the recumbent position. The lumbar puncture and the injection of pantopaque should be done with the patient lying face downward on the fluoroscopic table. The proper interspace can be identified by fluoroscopy, if desired. A small pillow under the abdomen will separate the spinous processes and make the patient comfortable.

The authors of this paper remark that removal of the pantopaque may be quite painful. This means only that a nerve root is being sucked against the needle. The aspiration should be done very slowly and, if pain occurs, the needle should be rotated 90 degrees. This manoeuvre will usually eliminate the pain.

The verified diagnostic accuracy of myelography has been reported by various authors as between 67 and 96 per cent. Key and Ford report 72 per cent. of accuracy in their series. We can say definitely that false positives occasionally occur. I recently saw a large constant filling defect, involving over half the width of the dural sac, with an absolutely negative exploration. Congenital arachnoid bands may account for some of these cases. A negative myelogram with operative findings of a true ruptured disc at the lumbosacral level occurs with some frequency. It is much more rare at higher levels. When operation has been decided upon and the myelogram is negative, the lumbosacral space should be explored first.

Dr. Toumey and his associates from the Lahey Clinic have presented a very timely paper on the similarity of symptoms of spinal-cord tumor to those of ruptured intervertebral disc.

In the five-year period from 1939 to 1943 at the Massachusetts General Hospital, the diagnosis of ruptured disc was verified at operation in 330 cases. During that same period there were fifteen cases of proved conus and cauda equina tumors,—a relative incidence of approximately 4 per cent. As Dr. Toumey has pointed out, it is usually impossible to make a differential diagnosis on clinical findings alone. In almost every instance, the patients with tumors had received orthopaedic treatment for back strain or for rupture of an intervertebral disc. In recent years, several patients who had unsuccessful operations for ruptured intervertebral discs, done elsewhere, have had tumors found at reoperation at our Clinic. There is only one way by which such catastrophies can be avoided,—*routine myelography.*

In any given case of low-back pain and sciatic pain, the decision to operate should be made on all the available evidence, not just on some of it. The history and physical findings are of paramount importance. The laboratory findings should be carefully interpreted in the light of the clinical picture. Myelography gives important evidence, even when it is negative, for a negative myelogram practically rules out spinal-cord tumor.

Dr. Key has said: "In view of these findings, the authors shall continue to use myelography in the study of patients with low-back pain, with or without sciatica, but probably only in selected cases." I can agree wholeheartedly with that statement if the method is used in every case in which surgery is contemplated and in which other studies have failed to produce an unequivocal diagnosis.

Dr. J. Albert Key (closing): We found four tumors in 206 operative cases; one of them, the intradural tumor, was recognized before operation. In the other three cases the myelograms were negative and the

(*Continued on page 306*)

CONTRACTURE OF THE THUMB WEB *

BY L. D. HOWARD, JR., M.D., SAN FRANCISCO, CALIFORNIA

So important is the thumb to the hand that its loss is considered a 50 per cent. disability. The mere presence of this digit is of limited value, however, unless the thumb web and the thumb joints are sufficiently mobile to allow motion of the thumb throughout a useful range. The thumb is, by virtue of its web, the only digit of the hand which can oppose the palm and the fingers. In this position the thumb can spread far from the fingers and also make contact with them.

In a crippled hand, contracture of the thumb web is common. It may be the principal cause of disability or it may be only part of a more complex problem. In either event, it is deserving of close attention, so that proper correction can be planned.

The thumb web may be defined as the soft parts between the metacarpals of the index finger and the thumb. Specifically, this includes the investing skin and subcutaneous tissue, and, within these, the important intrinsic muscles attached to the thumb

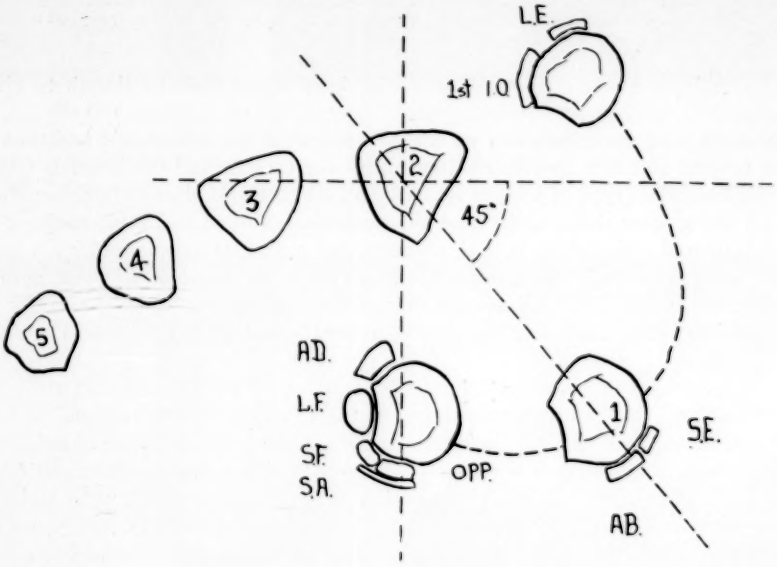

FIG. 1

Diagram of cross section of hand through metacarpal area shows relationship of thumb metacarpal (*1*) to index metacarpal (*2*) at point of maximum spread. The dorsal and volar adducted positions of the thumb metacarpal are also shown, with the muscles and tendons activated in assuming these positions.

1st I.O.: First interosseus.	*S.F.*: Short flexor.	*A.B.*: Long abductor.
S.E.: Short extensor.	*A.D.*: Adductor.	*S.A.*: Short abductor.
Opp.: Opponens.	*L.E.*: Long extensor.	*L.F.*: Long flexor.

ray. Only two of these, the abductor brevis and the opponens, act to open the thumb web. The others—the short flexor, adductor, and first interosseus—narrow the thumb web. In addition, the long tendons of the thumb—namely, the abductor, the short and long extensors, and the long flexor—although not confined to the thumb web, are

*Read at the Annual Meeting of The American Society for Surgery of the Hand, Chicago, Illinois, January 21, 1949.

FIG. 2-A FIG. 2-B FIG. 2-C

Fig. 2-A: Thumb-web contracture in aviator, following severe surface burn of hand.
Figs. 2-B and 2-C: Dorsal and palmar views showing correction by free skin graft, applied from hinge to hinge.

closely correlated in their action with the intrinsic muscles of the thumb to give web mobility.

The pillars of the thumb web are the metacarpals of the index finger and thumb; the former is fixed and in a specific relationship to the carpus, and the latter is mobile by virtue of the saddle type of joint at its base and also because of some intercarpal motion between the greater multangular and the navicular. The curved joint surfaces of the carpometacarpal articulation in both anteroposterior and lateral planes give a ball-and-socket type of motion within a limited range. This is the *hinge joint* of the thumb web. The proximal thumb joint also has mobility in other than the anteroposterior plane. This motion is both lateral and rotatory, thus further increasing the spread of the thumb as measured at its tip.

The maximum spread of the thumb web is obtained when the thumb metacarpal is about 45 degrees forward from the transverse plane of the index metacarpal or, roughly, the plane of the palm (Fig. 1). Here maximum action of the abductor muscles and the short extensor of the thumb is obtained. Motion in either direction from this position narrows the thumb web. Dorsally, the action of the long extensor tendon and the first interosseus muscle predominates until the dorsal adducted position has been reached. Toward the palm, the action of the opponens, adductor, and long and short flexors predominates until the palmar adducted position has been reached.

Thumb-web contracture is any limitation of the normal spread of the thumb away from the hand. It may be primary, where the immediate web structures are directly involved, or it may be secondary, as a result of extraneous factors. Whatever the cause, if the contracture lasts for any length of time, all web structures become shortened, including skin, fascia, muscles, and joint capsules.

PRIMARY CONTRACTURE OF THE THUMB WEB

Scars

Scars result from lacerations or from poorly placed surgical incisions. When they are not associated with soft-tissue loss or with irreparable injury to other web structures, they cause contracture only when they lie parallel or nearly parallel to the fold of the thumb web.

Treatment of such contracting scars consists in excision of the scar with local manipulation of the skin, such as a Z-plasty or a modification thereof.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Finger amputations and severe contractures of the thumb web and palm resulting from deep burns by phosphorus.

Fig. 3-B: Pedicle method used to replace soft parts and avoid secondary contracture after excision of all deep scar and opening of the hand. Note that Kirschner wires are being used for immobilization during healing. (*United States Army Photograph.*)

FIG. 4-A

FIG. 4-B

FIG. 4-C

Fig. 4-A: Extensive scarring and contracture of the thumb web following direct injury to web structures in a hand crippled by explosion of a booby trap.

Fig. 4-B: Hinge-to-hinge application of abdominal pedicle (direct flap could have been used) after excision of all scar and correction of contracture.

Fig. 4-C: Appearance following detachment of the pedicle. Note depth of cleft and good quality of cover, through which transferred opponens tendon can be placed. (*United States Army Photograph.*)

Burns

The scar from surface burns is a common cause of thumb-web contracture. The burn usually involves the dorsal surface of the web, but it may involve the volar surface as well or be so deep as actually to destroy some of the web structures beneath the skin.

Since a burn causes damage from without inward, treatment consists in excision of the resultant scar until a normal tissue bed has been reached. Cover is then replaced by a full-thickness or nearly full-thickness skin graft. In so doing, it is well to be generous in the amount of skin used and to make the correction from *hinge to hinge* (Figs. 2-A, 2-B, and 2-C). This is necessary, as there is always some contracture of a free graft. If the deeper structures are involved and the contracture is of long standing, full-thickness skin and subcutaneous tissue, as obtained by the pedicle or flap method, is preferred (Figs. 3-A and 3-B).

Direct Damage

Such injuries result in damage to all web structures and are due to missiles, infection, and crushing injuries. The crushing type of injury is common in industry and, when severe, is very resistant to correction.

If the loss is of great magnitude, excision of all scar and the spreading of the thumb web result in a large defect, which is best filled in from hinge to hinge by means of the pedicle or flap method (Figs. 4-A, 4-B, and 4-C). It is necessary to obtain full correction at the time of surgery; to do so may often require adductor release, stripping of that portion of the first interosseus muscle attached to the thumb metacarpal, or even capsulectomy of the thumb carpometacarpal joint. During the time of healing, it is well to maintain the thumb metacarpal in a position of maximum spread by means of two crossing Kirschner wires, transfixing the metacarpals of the thumb and index finger. This stops motion and promotes healing.

FIG. 5-A

FIG. 5-B

Fig. 5-A: Rifle-bullet wound through hand damaged tendons and metacarpal of index finger and produced thumb-web contracture due to scar.

Fig. 5-B: By amputation of the index finger and utilization of its skin (fillet), the thumb web was widened and good cover with sensation was provided to replace the dorsal scar in *one operative procedure*. (*United States Army Photograph.*)

When abdominal skin is used for restoration of the thumb web, either by tubed pedicle or by the direct-flap method, the preferred donor area has been found to be the lower portion of the abdomen on the same side as the injury. There is minimal strain in approximating the hand to this area, and the hand can be maintained in the position of function during the three-week period of attachment. To use the opposite side of the abdomen necessitates palmar flexion of the wrist, which is less advantageous.

In severely crippled hands in which thumb-web contracture is but a part of the general reconstructive problem, especially where the index finger has suffered extensive

FIG. 6-A

FIG. 6-B

Preoperative appearance and roentgenograms of hand crippled by machine-gun fire. Note angular deformity of thumb metacarpal due to malunion, and the severity of the web contracture, in spite of loss of the index finger with its metacarpal.

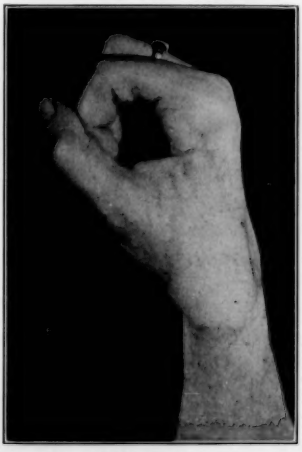

FIG. 6-C

FIG. 6-D

Postoperative appearance and roentgenograms after corrective osteotomy of thumb metacarpal and use of pedicle graft for soft-tissue defect. The pins were later removed. (*United States Army Photograph.*)

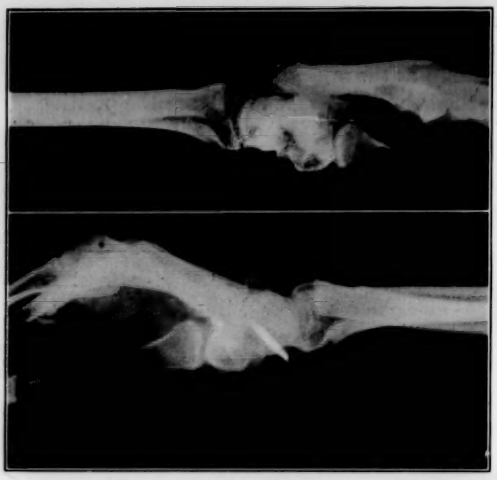

FIG. 7

Dorsal dislocation of metacarpals on the carpus. Note that index metacarpal now lies parallel to thumb metacarpal, thus narrowing the thumb web. Lower roentgenogram shows same hand after relocation of metacarpals. The thumb web has been re-established. (*United States Army Photograph.*)

damage, amputation of the index finger through the base of its metacarpal gives a prompt increase in the web between the thumb and the hand, and often supplies much-needed skin (by fillet of the index finger) to replace scar or to fill defects in the immediate vicinity (Figs. 5-A and 5-B).

Bones and Joints

1. Fractures of the thumb metacarpal may occur with malunion or non-union, in such a position as to narrow the thumb web (Figs. 6-A, 6-B, 6-C, and 6-D). Dorsal dislocation of the thumb metacarpal on the carpus, due to trauma; or scar contracture, as seen in severe burns on the dorsal aspect of the thumb, also results in web narrowing and loss of mobility.

Treatment consists in bone reconstruction, either osteotomy with correction of the alignment or bone-grafting in cases of non-union or loss of substance. Relocation of the thumb metacarpal on the greater multangular can be accomplished in recent traumatic cases; but in late cases, fusion of the carpometacarpal joint is generally necessary. Associated soft-tissue loss may require replacement by pedicle or flap at the time the bone surgery is done.

2. Fractures through the proximal half of the finger metacarpals, with malunion in dorsal angulation, result in a relative contracture of the thumb web. This is true in cases of fracture of the index metacarpal, and is perhaps more commonly seen when all metacarpals have been fractured. Dorsal dislocations through the carpometacarpal joints or through the distal portion of the carpus create the same type of deformity with relative thumb-web narrowing. Due to the resulting muscle imbalance, a claw position of the hand is generally assumed. Treatment consists in correction of the bone alignment (Fig. 7).

3. Traumatic arthritis of the thumb carpometacarpal joint, such as may follow an old Bennett's fracture or other injury, may give a mild degree of thumb-web contracture, due to limited mobility of this joint. When the arthritis is severe and associated with joint pain, it is best treated by arthrodesis with the thumb in the corrected position.

Ischaemic Contracture

Contracture and loss of function of the small muscles of the thumb web are commonly associated with neurovascular injuries of the arm; however, they may be local, involving one or more of the small intrinsic muscles. These are contractures of the Volkmann type and may have varying degrees of severity. The skin and subcutaneous tissues are not extensively involved, but become shortened secondarily as a result of the contracted position.

Treatment in such conditions is dependent upon the severity of the individual case. In mild involvement, tenotomy, excision, or a stripping operation may suffice. In severe involvement, it is well to excise all involved muscle from the thumb web. After this has been done, the skin is inadequate for full correction, and a large open area results, which cannot be covered satisfactorily. In such instances, it is best to fill the thumb web with

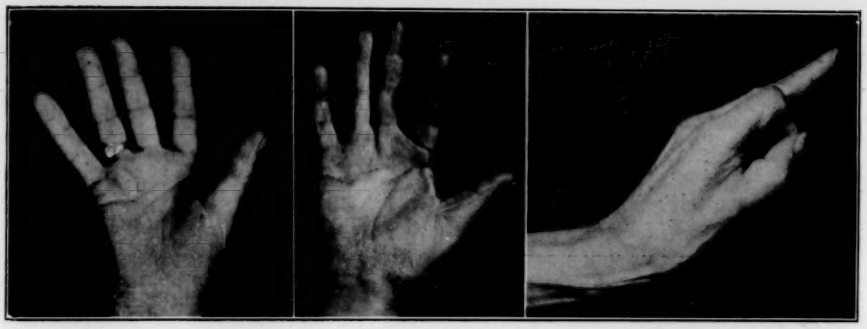

FIG. 8-A FIG. 8-B FIG. 8-C

Three cases of Dupuytren's contracture involving the base of the thumb and the thumb web in such a manner as to produce mild, moderate, and severe degrees of thumb-web narrowing. In the last case (Fig. 8-C), some type of skin replacement will be necessary.

good skin and subcutaneous fat by means of the pedicle or flap method. Tendon transfers and arthrodeses should be performed as indicated.

Dupuytren's Contracture

Occasionally Dupuytren's contracture is seen on the volar surface of the thumb web. It is usually of minor degree and produces only slight limitation. It can be remedied fairly well by excision of the involved fascia (Figs. 8-A, 8-B, and 8-C).

SECONDARY CONTRACTURE OF THE THUMB WEB

Secondary contractures of the thumb web are positional in origin. Therefore, any external restraining apparatus, such as a cast or splint, which does not allow full spread of the thumb web, will in time cause contracture, as the soft tissues of the thumb web shorten to accommodate for the relaxed position. The same condition may result from willful disuse, paralysis of muscles, or limited excursion of the tendons, which spread or allow spread of the thumb web unless motion is maintained passively. When these restrictions are of short duration, recovery is usually rapid following either active voluntary use of the hand or passive motions by means of elastic splints. Reparative surgery should be done, if indicated. When the restriction is prolonged, recovery is slow and often not complete.

CONCLUSIONS

1. The value of the thumb is dependent in large part upon the mobility of its web.
2. In thumb-web contractures, no matter what the cause, all soft-tissue web structures become shortened eventually.
3. For restoration of the thumb web, the hinge-to-hinge principle of correction should be used. This means that the new skin cover must reach from the hinge (carpometacarpal joint) on one side to the hinge on the other side.

DISLOCATION OF THE HIP ASSOCIATED WITH FRACTURE OF THE NECK OF THE FEMUR

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In a comprehensive survey of the literature, only thirteen cases of simultaneous fracture of the neck of the femur and dislocation of the femoral head have been uncovered. The first report of this lesion appeared in the form of an autopsy finding in 1798, in a Latin treatise by Haase. Twelve cases reported subsequently are considered authentic, having been confirmed by roentgenogram, or at operation or autopsy [1, 2, 4, 5, 9, 10, 12, 14, 15, 16]. At least one of these methods is necessary to identify the lesion. With the exception of two of these cases, most of those reported had inadequate treatment according to present standards, or had insufficient follow-up study to justify significant conclusions as to the clinical status.

One of the exceptional cases was reported by Funsten, Kinser, and Frankel. The patient, aged thirteen, had a fracture of the neck of the femur and a posterior dislocation of the femoral head; treatment, three weeks after the injury, consisted of operative reduction and fixation with an ivory peg. Five years later, there was aseptic necrosis of the head and shortening of one and one-quarter inches; motion was fair.

The other case presenting significant data was reported by Hart. This patient incurred a fracture of the femoral neck associated with anterior-inferior dislocation of the head; one month after the injury, the femoral head was removed and a Whitman reconstruction operation was done. Firm fusion, by chance, developed, and three years after the operation, function was excellent. This appears to be the only permanently successful result among the cases reported.

In this paper, two additional cases are presented; one is a personal case and the other, which has not been reported previously, was contributed by a colleague, J. A. Freiberg. The author's case is reported in detail with an evaluation of the result after a period of seven years.

Freiberg's patient, aged thirty, had suffered a fracture of the femoral neck and obturator dislocation of the head; three weeks after the injury he underwent open reduction and fixation with a Smith-Petersen nail. Ten weeks after the injury, a tibial-bone graft was applied in an effort to promote union, but without success. Finally, after a lapse of eight months, the femoral head was removed and a Whitman reconstruction operation was performed. Two years later, the range of motion was excellent; there was a slight limp; and the patient was employed on a milk truck.

Although it is not the purpose of this paper to discuss the occurrence of "surgical" fracture of the femoral neck, which may be incurred during attempted manipulative reduction of a simple dislocation, it is well to point out the danger of this serious complication. Many more cases of this nature have been reported than cases of traumatic fracture-dislocation, and undoubtedly the complication occurs even more frequently than has been recorded.

REPORT OF CASE

J.G.A., a dental officer, aged thirty-three, was injured on October 12, 1941, during military manoeuvres, when a truck in which he was riding ran into a tree. He probably sustained a "dashboard" type of injury to his hip, resulting in posterior dislocation of the right hip and fracture of the neck of the femur. The hip was immobilized in a spica. Twelve days after the injury, the patient was admitted to Walter Reed General Hospital, where roentgenograms were taken (Fig. 1).

An operation was performed the following day, with avertin-gas anaesthesia. After exposure of the hip through the Smith-Petersen incision, the fracture line was found to be almost horizontal. The femoral neck rested in the acetabulum. The head lay in a posterior and superior position; it was intact and was attached to a small fragment of capsule, but the ligamentum teres had been severed.

The neck was dislodged from the acetabulum and the head was replaced on the neck, it being necessary to enlarge the hole in the joint capsule, through which the head had made its exit, to effect replacement. A bone graft was used to transfix the fragments. The graft, of cortical bone and three inches in length, was obtained from the left tibia, and was tapered in order to promote impaction. It was driven from the articular surface into the neck, the fovea, which lay one-half inch from the margin of the fracture line, being used as the site of insertion. The graft was then cut, even with the articular surface. The reduction was satisfactory, and the fixation was quite firm. A small fragment which had become detached from the posterior border of the acetabulum was removed, and the dislocation was reduced. A single spica was applied, in which a Kirschner wire inserted in the lower femur was incorporated, to maintain traction.

Immobilization and traction were maintained for three months; at the end of that time they were supplanted by skin traction, which was continued for an additional three months. Weight-bearing was resumed after one year. Roentgenograms (Figs. 2-A and 2-B) demonstrate the healing at about that time. By June 1943, the patient was able to walk five miles daily. Roentgenograms revealed union of the fracture, with a zone of increased density at the fracture line. The head had been revascularized (Figs. 3-A and 3-B). Figures 4-A and 4-B illustrate the motion possible in the hip.

At that time, the patient requested duty overseas, although he was warned of the probable adverse effect of strenuous activity on the hip. He was assigned to field duty, and in April 1944, he completed the infiltration course and was walking twelve miles a day during training exercises. In September 1944, he was assigned to the China-Burma-India theater, where he remained until November 1945. During the course of examination at the separation center, he was admitted to the hospital. At that time, he experi-

FIG. 1

Anteroposterior view shows dislocation of the hip and fracture of the femoral neck, twelve days after injury. The head lies posterior and superior to the acetabulum, which contains the neck. The fracture line is horizontal.

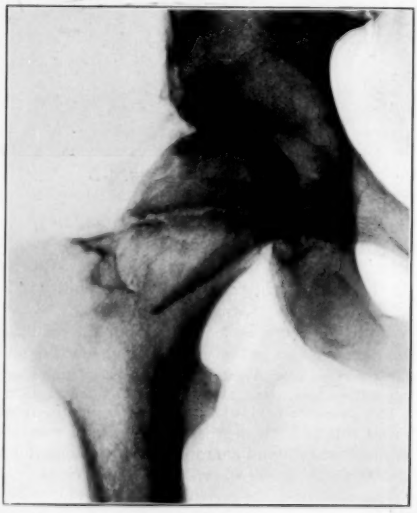

FIG. 2-A

FIG. 2-B

Anteroposterior and lateral views, on August 7, 1942, ten months after injury, show that the fracture is healing.

FIG. 3-A

FIG. 3-B

Anteroposterior and lateral views, on July 3, 1943, nearly twenty-one months after injury. The fracture is healed and the head has become revascularized. The lateral portion of the head shows cystic degeneration. The patient has practically normal function.

FIG. 4-A

FIG. 4-B

Photographs showing motion, two years after operation.

enced some pain in the thigh and knee during inclement weather, or after prolonged driving or standing, but pain in the hip was minimal. Joint motion was within 20 degrees of normal in all directions. Roentgenograms revealed moderate necrosis of the head and arthritis. The patient was retired for disability in May 1946.

At the time of the last examination, in July 1948, the patient complained of considerable pain at the hip after walking the distance of a block, but there was no pain when at rest or while sitting. The Trendelenburg test was positive. Squatting motion was performed fairly well. The extremity was one-half inch shorter, and the circumference at the mid-thigh one and one-half inches less, than on the normal side. Motions at the hip were as follows: maximum angle of extension, 165 degrees; flexion, 75 degrees; range of motion, 90 degrees; abduction and adduction, 15 degrees; external rotation, 10 degrees; and internal rotation, 5 degrees. Roentgenograms revealed union of the fracture, degeneration and compression of the superior portion of the head, and advanced arthritis (Figs. 5-A and 5-B).

DISCUSSION

The prognosis of this unusual injury is far less favorable than that in other types of fracture-dislocation involving the hip. To a large extent the outcome, when the femoral

FIG. 5-A

FIG. 5-B

Anteroposterior and lateral views, seven years after injury. There is necrosis of the head with sequestration of its superior portion, and severe arthritis.

head has been preserved in treatment, depends upon whether or not aseptic necrosis of the head ensues. When the femoral head has been removed in treatment, the displacement of the neck and greater trochanter upward is the primary factor responsible for continued disability.

It is apparent that in this combined injury the dislocation occurs before the fracture is complete, since the external force must be exerted through the intact femoral neck or through the incompletely fractured neck, in order to dislocate the head. The force, if it is not spent, then causes a complete break in the continuity of the neck and the fragments are displaced, usually to a considerable degree.

Primary operative treatment is indicated in this injury. It is improbable that a reduction could ever be accomplished by manipulation alone, since the femoral head in such an injury cannot be controlled through the shaft. The difficulties encountered at operation indicate that closed manipulation is futile.

Another approach to treatment, which is not advisable, was suggested by Henry and Bayumi, who considered that a successful result might follow reduction of the dislocation after union of the fracture. Such treatment is based upon the prerequisite of good apposition of the fragments, but such is seldom the case. Moreover, the reduction of a dislocation of long standing is difficult, and offers little, if any, chance of a useful hip being obtained. The follow-up period in Hoeftman's case, in which this method of treatment was used, was too short to permit estimation of the outcome.

There are two alternative primary operative measures to which the surgeon may resort in treatment: (1) reduction, which may be attempted when the femoral head is intact; or (2) removal of the head, followed by a reconstruction operation. When reduction has been successful, one of two supplementary measures may be carried out: (1) fixation of the head to the neck by a graft or nail; or (2) primary osteotomy of the McMurray type, such as is used in treating fracture of the neck of the femur. No report on the use of the latter operative measure in fracture-dislocation has appeared.

The principle of reduction and fixation was carried out by Hey Groves [7] in the case

of a woman, forty-four years old, who had fractured the femoral neck two years before. At operation, Hey Groves dislocated the femoral head and performed proximal pegging of the head to the neck. The case was followed for eighteen months, but the outcome is unknown. Hey Groves [6] preferred pegs of beef bone or ivory to those of autogenous bone.

Experiments along the same line were carried out by Henry [11]. After fracturing the femoral neck and dislocating the head in each of fifteen dogs, Henry, by a proximal pegging, transfixed the fragments with a steel screw. Seven of the dogs obtained "useful" hips. In view of this success, Henry felt that the procedure had clinical application, but he suggested the use of an autogenous screw in the human.

It was essentially this principle upon which the author based the treatment of the case described. The early result was good, and one wonders what would have been the final outcome, had a less vigorous course been pursued during the early postoperative years. On the other hand, there is always the danger that aseptic necrosis may develop as a result of such treatment, and in view of the frequent occurrence of this sequela in the isolated dislocation or fracture of the neck, its appearance in the combined injury seems inevitable. In retrospect, after observing the subsequent course of the patient for seven years, the better treatment might have been the alternative method of removing the head. The nature of the fracture was such that the stump of the femoral neck could have been inserted into the acetabulum.

Removal of the femoral head, followed by a reconstruction operation, is the treatment of choice. Watson-Jones stated: "It is better, therefore, if manipulative reduction has failed, to excise the loose head, and after downward displacement of the trochanter to place the neck of the femur in the joint as in a Whitman's reconstruction operation".

Reconstruction measures are as follows: (1) insertion of the neck into the acetabulum; (2) primary fusion; (3) trochanteric cup arthroplasty; and (4) primary replacement of the head by a device such as a metallic prosthesis. In Hart's case in which a Whitman reconstruction operation was carried out, the result was excellent four years after operation, with the hip completely ankylosed. An excellent result was obtained in Freiberg's case by a Whitman operation, performed late.

No case has been reported in which fusion of the hip joint was the primary method of treatment, but excellent function resulted in Hart's case following ankylosis. Similarly, no case of primary cup arthroplasty has been reported, but excellent results have followed this method in related conditions.

Primary replacement of the head by a device such as a metallic prosthesis is still in the experimental stage, and no report has yet been published. Treatment based on this principle would preclude the development of aseptic necrosis, as well as permit early function.

In the case presented, further surgery, in the form of one of the reconstruction measures that have been outlined, will probably be required.

SUMMARY AND CONCLUSION

Two cases of the unusual combined injury of fracture of the femoral neck and dislocation of the hip have been presented. One personal case was followed for a period of seven years after operative reduction and primary fixation by a bone graft. After nearly five years of unlimited activity, necrosis and severe arthritis developed.

The author believes that primary removal of the femoral head, followed by a reconstruction operation, is justified.

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(*Continued from page 248*)

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THE OCCURRENCE OF CALCANEONAVICULAR SYNOSTEOSIS IN PES VALGUS CONTRACTUS

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A study of the literature gives the impression that calcaneonavicular synosteosis is a rare affection. Pfitzner, however, found "concrescentia calcaneonavicularis" in 4 per cent. and calcaneonavicular synosteosis in 2.9 per cent. of 520 foot skeletons.

It is well known that calcaneonavicular synosteosis occurs in combination with pes valgus contractus. In the authors' experience, this combination occurs much more frequently than is generally assumed. During a period of three months, we personally found four instances of synosteosis of the calcaneus with the navicular in five cases of spastic flat-foot.

In descriptions of roentgenographic findings, synosteosis is rarely mentioned. Slomann was the first to draw attention to it when, in 1920, he demonstrated five cases of "abnormal, congenital continuity between the anterior extremity of the calcaneum and the navicular bone". The synosteosis had been known to exist from anatomical reports, but *in vivo* this diagnosis had not yet been proved. Slomann observed his five cases within a period of a few years. As a rule, roentgenograms of the foot are made in two planes,—namely, dorsoplantar and mediolateral. In these projections the adjoining portions of the calcaneus, the talus, and the navicular overlap. The synosteosis, which occurs exactly in this region, is consequently often overlooked.

In order to prevent this, Slomann advised a special projection, in which the plantar surface of the foot rests on the plate at an angle open medially, the central ray falling perpendicularly on the plate. He was convinced that, if more roentgenograms were taken with the foot in this position, the synosteosis would be found in a considerable number of cases. In the projection advocated by Slomann, an empty space is seen in the normal foot between the distal upper portion of the calcaneus, the distal lower portion of the talus, and the lower portion of the navicular (Fig. 1-A). In cases of synosteosis, a continuous bone bridge is seen between the calcaneus and the navicular (Fig. 2-B). It is, however, easier to have the plantar surface of the foot rest on the plate and to have the central ray enter laterally at an angle of 45 degrees (position of Chaumet and Ferry[1]).

Slomann distinguished three forms or degrees of synosteosis:

1. The complete bone bridge (Figs. 2-B, 3-B, 4-A, and 4-B).
2. The fibrous cord, or syndesmosis. In syndesmosis one or more osseous bodies (ossa

FIG. 1-A
Normal foot.

FIG. 1-B
Arrow points to small osseous body.

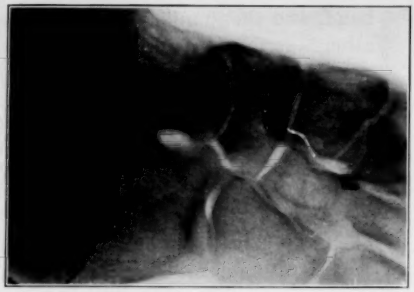

FIG. 2-A

FIG. 2-B

Fig. 2-A: Amphiarthrosis, with protuberances on the calcaneus and navicular, resembling joint facets.
Fig. 2-B: Bone bridge in calcaneonavicular synosteosis.

FIG. 3-A

Amphiarthrosis.

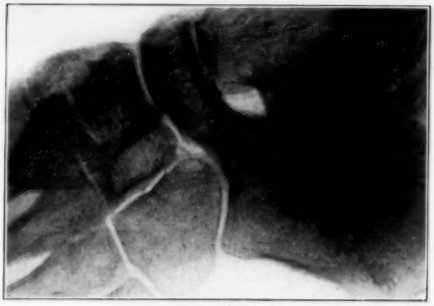

FIG. 3-B

Complete bone bridge.

calcanea secundaria) are often found embedded in the fibrous tissue (Fig. 1-B, arrow).

3. The amphiarthrosis, a kind of stiff joint between abnormally well developed protuberances of the calcaneus and the navicular (Figs. 2-A and 3-A).

It is impossible to demonstrate syndesmosis or amphiarthrosis directly with roentgen rays, but if ossa calcanea secundaria are found, together with the clinical phenomenon of pes valgus contractus, the authors believe that the diagnosis of calcaneonavicular syndesmosis is justified. The amphiarthrosis may be identified by the finding of abnormally well developed protuberances on the sides of the calcaneus and the navicular which are facing each other, particularly if the ends of the protuberances resemble joint facets. (This is shown clearly in Figure 2-A.)

Of course, many intermediate forms exist between the normal picture, on the one

FIG. 4-A

FIG. 4-B

Complete bone bridge.

FIG. 5

Intermediate form with strong development of the anterior portion of the calcaneus.

hand, and the amphiarthrosis, on the other,—forms in which the anterior portion of the calcaneus is more or less strongly developed (Fig. 5).

The clinical picture of pes valgus contractus has been beautifully described by Paul Padovani. He rightly pointed out that in pes valgus contractus, combined with calcaneonavicular synosteosis, the foot is more painful than flat; so we may often call it a slight pes cavus. The bone bridge between the calcaneus and the navicular prevents plantar torsion of the head of the talus; this would explain the fact that the normal longitudinal arch is maintained. In ordinary flat-foot we often find roentgenographically a distal shifting of the talonavicular joint in respect to the calcaneocuboid joint. This phenomenon is, of course, not found in flat-foot with synosteosis.

The authors do not intend here to go into the theories of the etiology of pes valgus contractus in general, or of synosteosis in particular. In this connection, Todd wrote: "Not much is to be gained by a perusal of recent surgical literature on this subject". Again he stated: ". . . the most I can hope to do is to give a concise summary of the present state of our ignorance". There are many theories as to the causes of spastic flat-foot, such as: overburdening, inflammation ("tonsil flat-foot"), general symptoms of degeneration, trauma, irritation of the peroneal nerve, congenital abnormalities, and reflex spasm due to irritation of one of the parts of the lower tarsal joint. At present most authors prefer the latter theory. Overburdening certainly is an important factor, as is shown by the occurrence of spastic flat-foot among adolescents engaged in hard work, and in men in the military forces.

CONCLUSIONS

1. The combination of spastic flat-foot with calcaneonavicular synosteosis occurs more frequently than is generally believed.

2. In all cases of spastic flat-foot, it is advisable to take roentgenograms in three planes,—namely (a) dorsoplantar, (b) mediolateral, and (c) at an angle of 45 degrees (method of Chaumet and Ferry).

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EXPERIMENTAL EVALUATION OF HOMOGENOUS BONE GRAFTS

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The healing and repair of bone is an orderly and uniform process, similar in basic fundamentals to other tissue repair. Many of the important steps remain unexplained. However, the fixation and replacement of bone grafts elicits the same pattern of bone growth and repair as is found in other instances of bone healing. There remains, at the present time, divergent opinion as to the fate of autogenous bone grafts and the relative importance of the various structures of the transplanted bone and the host bone. Similar confusion exists as to the fate of transplanted homogenous bone. As a result, two schools of thought have arisen in regard to bone transplantation, probably based upon different interpretations of essentially the same experimental observations. The first group includes those who believe that some element of the transplanted bone lives and is capable of regeneration. In the second group are those who believe that the entire bone transplant dies and is completely replaced by osteogenic elements of the host. Because of the important clinical implications of these widely divergent views, an experimental comparison of autogenous and homogenous bone transplants has been made.

HISTORICAL BACKGROUND

As stated by Keith, Belchier, Duhamel, Haller, Syme, Goodsir, Flourens, and others laid the foundation for the experimental work on bone transplantation, presented by Ollier in 1867. According to Keith, Ollier had postulated that true transplantation of bone was possible only with living, autogenous, periosteum-covered bone, and that every other kind of bone transplant could be expected to die and become a foreign body. It should be remembered that these observations were made without the aid of microscopic examination or control of asepsis.

Bonome, in 1885, contended that the bone of even an autogenous graft dies, but the transplanted periosteum maintains its osteogenetic properties. Barth, in 1893, concluded from his carefully performed experiments that all elements of transplanted bone die and are slowly replaced by newly formed bone from the adjacent bone-producing tissues. On the other hand, Axhausen, Mayer and Wehner, Haas, Brooks, Phemister, Ham, Rohde, Albee, and others have contended that some elements of the bone transplant survive and are capable of osteogenesis. Even among these workers, there is difference of opinion as to the relative osteogenetic importance of the periosteum, endosteum, and the cells lining the Haversian systems of the transplant. It is generally agreed that the mature osteocyte has no reproductive or regenerative power, and plays no part in the fixation and replacement of bone grafts.

Clinical homogenous transplantation of bone was first performed successfully by Macewen in 1880. Lexer, Gill, and May successfully transplanted homogenous joints. Gallie and Robertson reported the successful use of boiled autogenous, homogenous, and heterogenous bone. Hey Groves and Albee confirmed these findings. Orell, in 1937, demonstrated the successful use of preserved homogenous and heterogenous bone, which he termed "os purum" and "os novum". Inclan, Ghormley, Bush, Wilson, and others have more recently reiterated the clinical value of preserved homogenous bone grafts.

It is evident from an analysis of the literature that, if any of the elements of a bone graft remain viable and retain their osteogenetic properties, the fixation and replacement of these grafts should occur at a much faster and more uniform rate than in those grafts known to be totally dead. Furthermore, it would seem that, if *all* transplanted bone

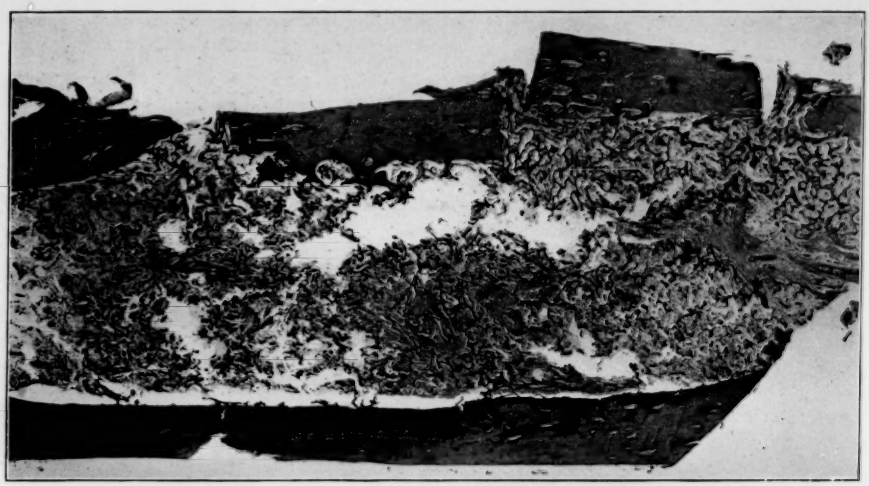

FIG. 1

Merthiolate and Autogenous Grafts (× 5)

Two inlay grafts occupy the tibial defect in the left leg. The proximal graft (at the reader's left) is fresh autogenous bone; the distal graft is merthiolate-preserved homogenous bone. Shows the appearance at the end of three weeks. Note the osteoid trabeculae filling the marrow cavity and their apposition to the endosteal surfaces of the grafts. Osteoid union is present at the graft junctions.

becomes totally dead, the recognized superiority of autogenous grafts over homogenous grafts is open to question.

The authors have attempted in this experiment to re-evaluate the stated concepts and to compare critically, under identical experimental conditions, grafts of autogenous bone and of various types of preserved homogenous bone.

EXPERIMENTAL PROCEDURE

The procedure used was devised to comply with three experimental conditions. First, the extrinsic factors of bone repair—such as immobilization, a constant graft bed, and circulation—should be standardized and made uniform. Second, a technically simple but morphologically significant means of comparing the bone grafts with surrounding normal bone, in a single microscopic section, was desired. Third, a similar method in which different types of homogenous grafts could be compared with each other and with normal bone under identical conditions was deemed necessary. It was felt that small inlay grafts would best comply with these requirements.

Therefore, in adult dogs, an area of the proximal portion of the tibia, about 2.5 centimeters from the tuberosity, was exposed on each leg, sterile conditions being maintained. The periosteum was incised longitudinally and was elevated. By means of a small motor saw in most instances, a rectangular block of bone, measuring approximately 2.5 by 1 centimeters, was removed from the medial portion of the cortex of each tibia.

In ten dogs, the grafting was done as follows: In the left leg, the proximal half of the defect was filled with autogenous bone removed from the contralateral tibia, and the distal half was filled with a fitted homograft from the merthiolate bone bank* (Fig. 1). In the right leg, the proximal half was filled with autogenous bone from the contralateral tibia and the distal half with homogenous frozen bone (at −20 degrees centigrade) (Fig. 2).

In six dogs, after similar defects had been prepared in the proximal portion of the

* The merthiolate bone bank consists of homogenous dog bone preserved in an aqueous solution of 1:1000 merthiolate for two weeks, and in 1:5000 merthiolate solution thereafter. This bone will be referred to as "merthiolate bone" throughout this paper.

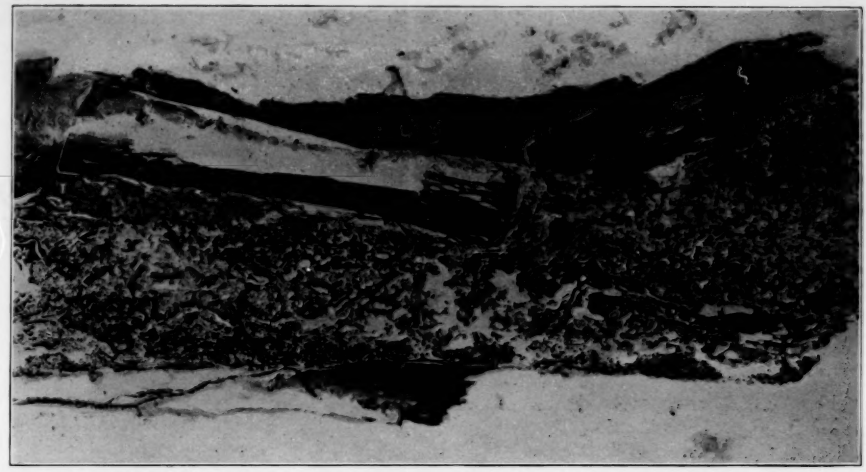

FIG. 2

Frozen and Autogenous Grafts (× 5)

In the right leg the proximal graft (at the reader's left) is fresh autogenous bone; the distal graft is homogenous cortical bone, preserved by refrigeration at minus 20 degrees centigrade for four weeks. The absence of the outer two thirds of the autogenous graft is an artifact in sectioning.

At the end of three weeks, osteoid trabeculae fill the marrow cavity and are growing by apposition to the endosteal surfaces of the grafts. Osteoid fills the graft junctions.

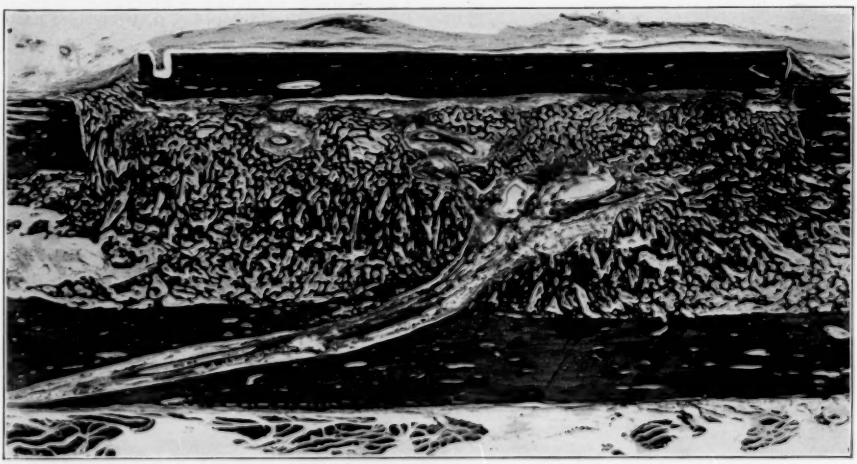

FIG. 3

Merthiolate Graft Alone (× 5)

A single inlay graft of merthiolate-preserved homogenous bone occupies the tibial defect in the left leg. This graft measures approximately 2.5 by 1.0 centimeters.

At the end of three weeks, the marrow cavity is completely filled with osteoid trabeculae, known to arise from host tissues. Note their radial arrangement to the graft. Organized hematoma tissue is still present beneath parts of the endosteal surface, but osteoid has apposed itself to this surface in some areas (see Fig. 9). Osteoid union is present between the graft and normal cortex.

tibia, single inlay grafts, measuring approximately 2.5 centimeters in length (Fig. 3), were inserted as follows: Cortical bone from the merthiolate bone bank was used on the left side, and autogenous bone from the contralateral tibial defect was used in the

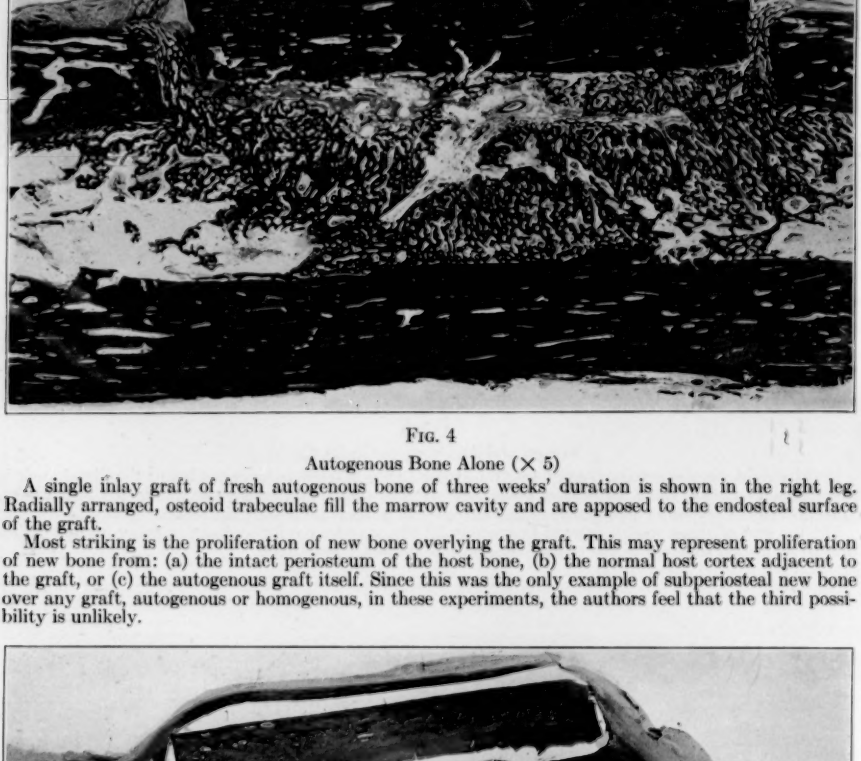

FIG. 4

Autogenous Bone Alone (× 5)

A single inlay graft of fresh autogenous bone of three weeks' duration is shown in the right leg. Radially arranged, osteoid trabeculae fill the marrow cavity and are apposed to the endosteal surface of the graft.

Most striking is the proliferation of new bone overlying the graft. This may represent proliferation of new bone from: (a) the intact periosteum of the host bone, (b) the normal host cortex adjacent to the graft, or (c) the autogenous graft itself. Since this was the only example of subperiosteal new bone over any graft, autogenous or homogenous, in these experiments, the authors feel that the third possibility is unlikely.

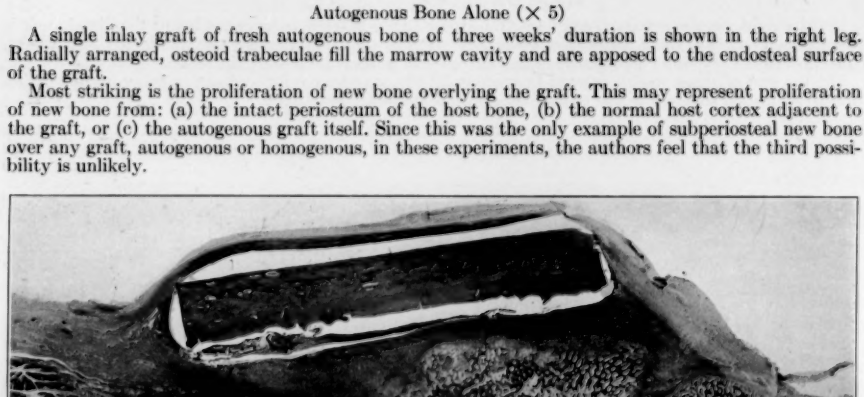

FIG. 5

Boiled Bone Alone (× 5)

In the left leg, the boiled homogenous graft is completely extruded from the tibial defect at the end of three weeks, and is surrounded by a reactive sac of fibrous tissue. In sectioning, only a portion of the operative defect in the host cortex is shown.

Beneath the dense fibrous tissue about the graft are abundant trabeculae of new bone. At this area, most of the new bone is being produced by the periosteum of the host.

Because of the foreign-body reaction of this graft, revascularization and replacement by appositional growth of new bone is impossible. Such a graft is certain to fail.

right leg (Fig. 4). In another six dogs, homogenous bone grafts that had been boiled for ten minutes and kept under sterile conditions were placed in the left tibial defects (Fig. 5), and autogenous control grafts were placed in the tibial defects on the opposite side.

The inlay grafts were fitted as tightly as possible. No attempt was made to repair the periosteum and replace it over the defects. Closure of the wounds was accomplished in layers with silk sutures. The legs which had been operated upon were not immobilized in any of the experiments.

The dogs were sacrificed in such a manner that specimens were obtained for study at weekly intervals up to ten weeks. These specimens were first fixed in 10 per cent. neutral formalin and later were decalcified in a 20 per cent. solution of formic acid and sodium citrate.

EXPERIMENTAL RESULTS

Certain factors or criteria of healing were decided upon to form a comparison of the autogenous and various types of homogenous grafts. For simplicity of description, the experimental findings will be discussed collectively under each of these arbitrary factors, and any variation in the individual grafts will be elaborated upon. These factors have been listed as nearly as possible in the order of their appearance.

Organization of Hematoma

The hematoma which forms in response to trauma occupied the marrow cavity beneath the grafts. Organization of this structure occurred in a uniform manner and rate in all of the specimens. Young, undifferentiated mesenchymal cells appeared to arise from the endosteum of normal bone and possibly from perivascular tissue and to move from the periphery into the fibrin-enmeshed hematoma. These cells, polygonal and spindle-shaped, usually showed three or four fine, tapering fibrils which formed a delicate lacework with those of adjacent cells. Little or no collagen production occurred. Numerous young budding capillaries accompanied the proliferating mesenchymal cells.

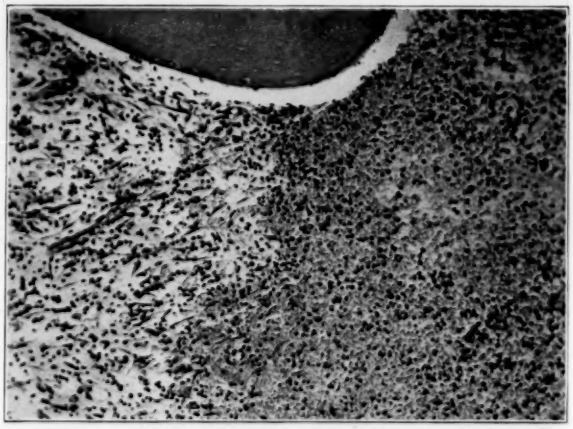

FIG. 6-A (× 60)

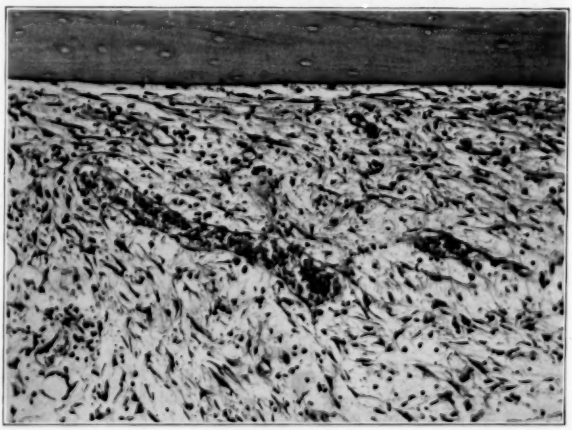

FIG. 6-B (× 85)

Organization of Hematoma

The organized hematoma beneath a merthiolate-preserved homogenous graft of seven days' duration is shown. Note the young, undifferentiated mesenchymal cells and the dilated, budding capillaries.

Complete organization of the hematoma occurred in all of the specimens within a period of one week (Figs. 6-A and 6-B).

Proliferation of Osteoid Tissue

Proliferation of osteoid trabeculae followed immediately the organization of the hematoma. The exact nature of this process is obscure at present. Undoubtedly, some factor influences the young undifferentiated mesenchymal cells to become bone-producing cells. By definition, the authors agree with Ham, Rohde, and others that the term metaplasia or metaplastic bone formation is incorrect. It is better to consider this process as the response of undifferentiated multipotential mesenchymal cells to an "organizer", which in this instance calls for the production of bone.

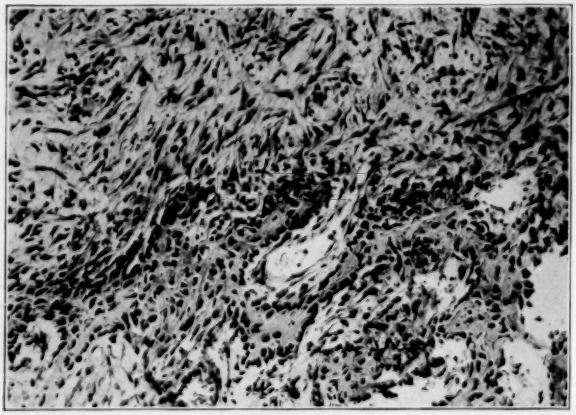

FIG. 7-A

Proliferation of Osteoid (× 85)

This section is taken from the periphery of the organized hematoma beneath autogenous and merthiolate grafts of seven days' duration. Note the differentiation of the primitive mesenchymal cells at the tips of the finger-like trabeculae of osteoid.

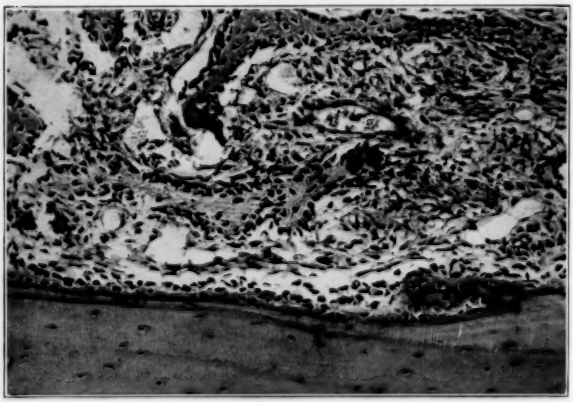

FIG. 7-B

Proliferation of Osteoid (× 85)

This field shows the endosteal surface of the normal cortex exactly opposite the operative defect. Note the intense "osteoblastic" activity of the endosteum and the proliferation of osteoid trabeculae. The intertrabecular spaces are filled with undifferentiated mesenchymal tissue.

The osteoid tissue first made its appearance at the periphery of the organized hematoma and grew into it by slender finger-like trabeculae (Figs. 7-A and 7-B), arranged in radial position to the grafts. The mesenchymal cells at the tips of the trabeculae became fatter and more polygonal, and their fibrils were shorter and broader. The production of osteoid tissue appeared to be an inherent property of the cell itself. Since the initial appearance of this tissue was always at the periphery of the hematoma and in close relationship with the endosteum of the normal bone, the production of osteoid is probably a host response in the process of healing. Further evidence of this contention is that osteoid trabeculae were seen in approximately equal amounts in all sections at the end of one week. In the succeeding weeks, the proliferation of osteoid trabeculae continued uniformly, completely occupying the marrow cavity, to eventually engulf the endosteal surfaces of the grafts and the graft junctions. No consistent difference could be found in the proliferation of osteoid tissue, regardless of the type of graft used.

As was stated before, observations related to the periosteum and its production of osteoid cannot be considered valid in these experiments, because no consistent attempt to restore this structure to its normal position was made at operation. However, in those sections in which periosteum was present, osteoid production was seen in small amounts only, and always at the junction of grafts with normal bone. No periosteal-covered grafts, either autogenous or homogenous, were used; hence viability of this structure, when transplanted, cannot be ascertained.

Appositional Bone Growth

One of the most striking and important phases of healing of bone grafts is the appositional growth of osteoid and immature bone along the surfaces of the bone transplant. The authors feel that within this process lie most of the confusion and misinterpretation as to whether the osteoid tissue comes from the graft or from the host. Barth was the first to demonstrate this process clearly, and to call attention to its importance in the fixation and replacement of bone grafts. We shall attempt to describe this phenomenon in detail, as observed throughout these experiments.

In between one and two weeks, the osteoid trabeculae reached the endosteal surface of the transplanted bone (Figs. 8-A and 8-B), being most abundant at the junctions of the graft and the host bone. These trabeculae apposed themselves intimately to the endosteal surface of the grafts, and a single layer of osteogenic cells often appeared to creep along the transplant in advance of osteoid production (Fig. 9). As calcification and ossification of the osteoid occurred, a distinct "resting line" was always discernible between the new appositional bone and the transplanted bone.

By the end of four weeks, this process had involved the entire endosteal surfaces of all autogenous grafts, and all types of homogenous grafts except the boiled bone. In the boiled-bone grafts, appositional growth to the endosteal surface was not evident until the sixth week. It appeared

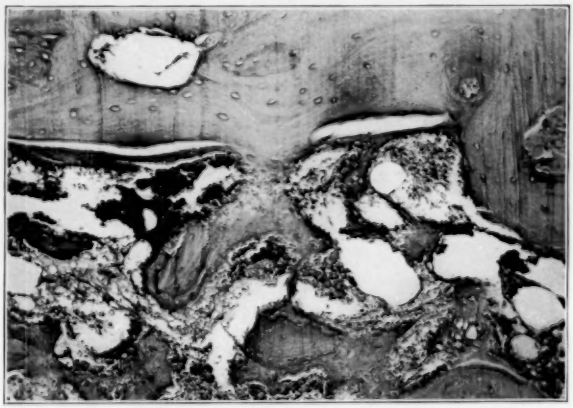

FIG. 8-A

Appositional Bone Growth (× 85)

Shows appositional growth of new bone to the endosteal surface of a merthiolate-preserved homogenous graft of two weeks' duration. Since the merthiolate graft is known to be dead, the appositional bone is obviously produced by the host tissue.

FIG. 8-B

Shows an identical process of appositional growth of new bone to the endosteal surface of an autogenous graft of two weeks' duration.

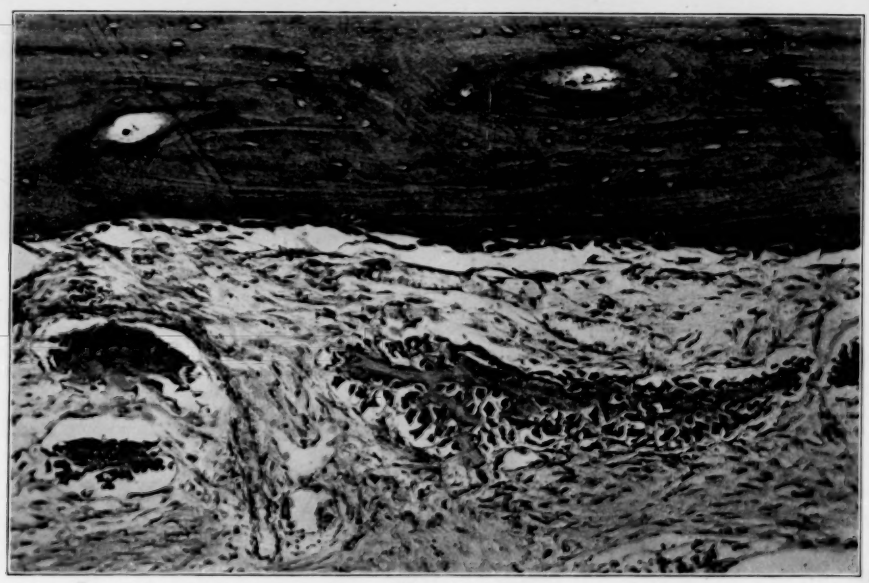

FIG. 9

Appositional Bone Growth (× 70)

"Osteoblasts", arising from the primitive mesenchymal cells of the host tissues, are seen to be growing along the endosteal surface of a known dead merthiolate graft (three weeks' duration) and are producing osteoid tissue. Misinterpretation of this appositional growth of host tissues is the source of much of the confusion regarding viability of bone grafts.

that the process of appositional bone growth occurred but slightly earlier in the autogenous grafts than in the frozen or merthiolate-preserved homogenous bone (Figs. 10-A and 10-B).

The microscopic appearance of early appositional bone upon the surface of transplanted autogenous grafts has undoubtedly led to the belief of many workers that cells of the transplant lived and were osteogenic. It seems clear from the authors' observations that appositional bone growth is a function of the host tissues, and is totally unrelated to the viability of the graft. Evidence of this contention is demonstrated by the appearance of appositional bone growth on known dead homogenous grafts in an identical manner and at essentially the same time as in autogenous grafts (Figs. 8-A and 8-B).

This process of appositional growth of the host bone continued in a uniform and orderly fashion in all the grafts observed during the succeeding weeks. In this experiment, the fixation and replacement of the transplanted bone was entirely the function of appositional bone growth. Subperiosteal bone proliferation appeared late.

Osteoclastic Activity

The homogenous bone grafts appeared to incite a greater osteoclastic response than the autogenous bone. However, consistent action of the osteoclast was not evident, except at the periosteal surface and the peripheral ends of all types of grafts. These cells were first noted in specimens of two weeks' duration, and persisted in varying numbers in all sections of the succeeding weeks.

It appeared that osteoclastic activity was of greater significance in the remodeling of newly formed trabeculae of the medullary cavity than in resorption of the grafts.

Union of the Grafts

Union of the grafts with host cortical bone was accomplished by osteoid proliferation

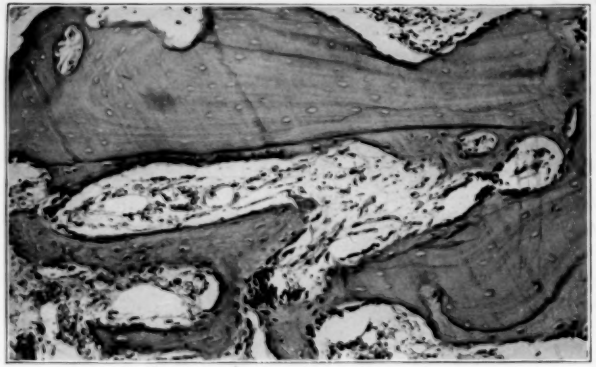

FIG. 10-A

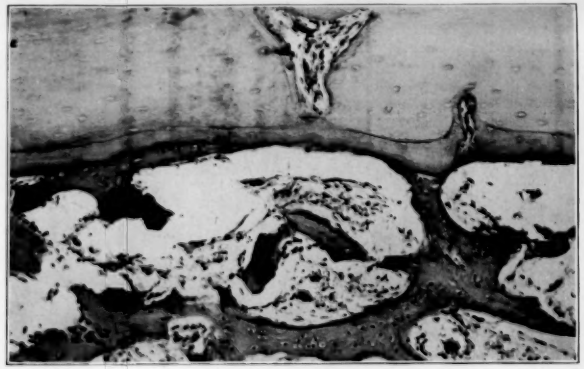

FIG. 10-B

Appositional Bone Growth (× 85)

Figs. 10-A and 10-B: A comparable degree of appositional growth of new bone to the endosteal surfaces of a merthiolate-preserved homogenous graft (Fig. 10-A) and a fresh autogenous graft (Fig. 10-B) is present. Both grafts are of three weeks' duration.

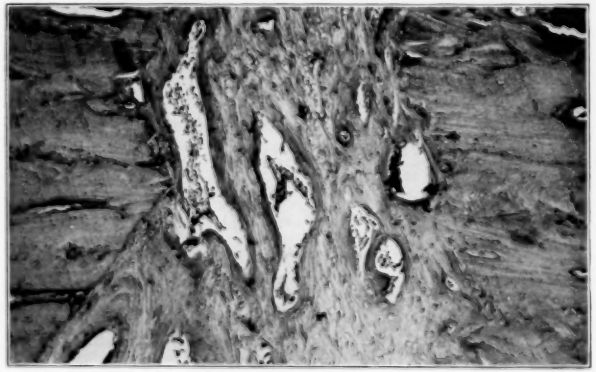

FIG. 11-A

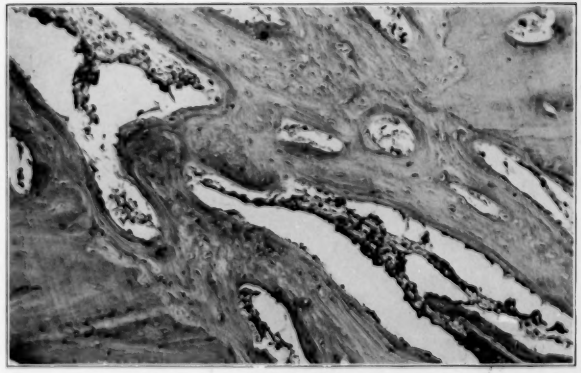

FIG. 11-B

Union of the Grafts (× 65)

Figs. 11-A and 11-B: The junctions between merthiolate-preserved graft and normal host cortex (Fig. 11-A) and an autogenous graft and host cortex (Fig. 11-B) are shown at four weeks. Note the identical union by bone in both specimens.

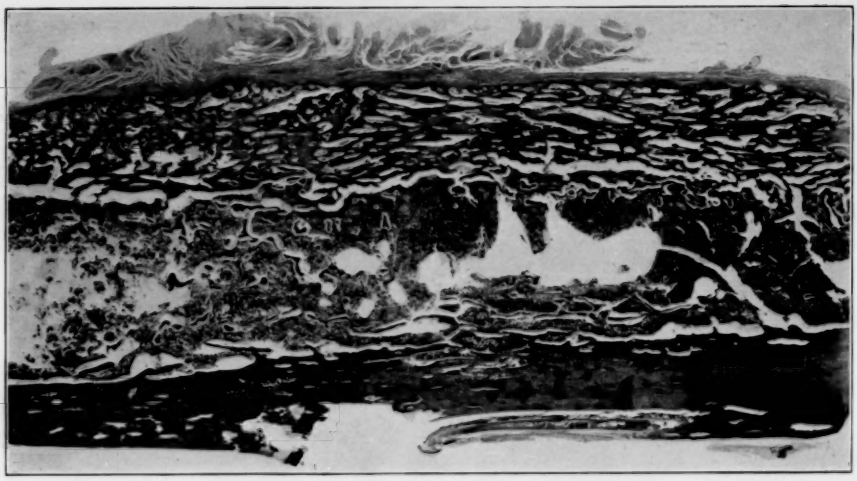

FIG. 12-A (× 5)

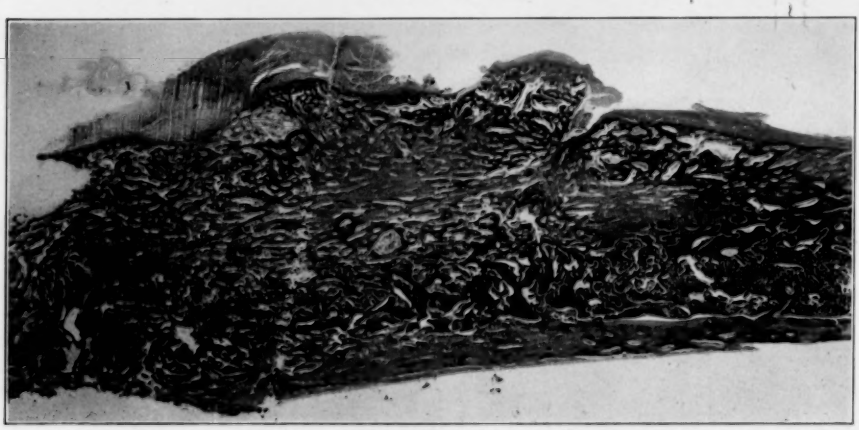

FIG. 12-B (× 5)

Union of the Grafts

The appearance of merthiolate and autogenous grafts of eight weeks' duration is shown in Fig. 12-A. The merthiolate graft is at the left and the autogenous graft at the right. The graft junctions are indistinct and the normal relationship between the cortex and the marrow cavity has been restored. In Fig. 12-B a similar appearance is shown with frozen homogenous bone (at the left) and autogenous bone (at the right) at nine weeks. A small abscess is present beneath the frozen graft.

in the junctions, followed by ossification and appositional bone growth, as previously described (Figs. 11-A and 11-B). Osteoid union was evident at the end of three weeks in all grafts except those of boiled bone. Union of boiled-bone grafts and the host did not occur microscopically until six weeks. In both autogenous and homogenous bone, the junction between grafts and host was almost indistinct at eight weeks (Figs. 12-A and 12-B).

Revascularization of the Haversian Canals

Revascularization of the Haversian canals was accomplished by ingrowth of young capillaries from the host tissue into and along the extent of these structures.

Evidence of this observation is afforded by the fact that revascularization began first in the innermost aspects of the grafts, or those closest to the richly vascular host

tissue, and only later were the Haversian canals of the outer portions of the graft revascularized (Fig. 13).

There is little doubt from the authors' observations that revascularization of the canals proceeds at a more rapid and uniform rate in the autogenous grafts than in the homogenous grafts, being evident in significant degree at three weeks in the former and at four weeks in the latter. The complete import of this is not understood at the present time, since all Haversian canals in both autogenous and homogenous grafts were revascularized at eight weeks.

Haversian-Canal Proliferation

By this term, we denote an important phenomenon by which undifferentiated mesenchymal cells invade the revascularized Haversian canals, line up against the canal walls, and begin to form osteoid tissue. This process was identical in every way to appositional bone growth on the endosteal surfaces of the grafts. It followed the revascularization of the canals by approximately one week, and hence began in the inner portion of the grafts and progressed outward in the succeeding weeks. Also, the process was seen slightly earlier in autogenous transplants than in those of homogenous bone. A significant degree of Haversian-canal proliferation was seen in autogenous grafts at four weeks, while a comparable picture was seen in homogenous grafts at five weeks (Figs. 14-A and 14-B). This process was greatly retarded in the boiled-bone grafts of the experiments, being but poorly developed at six weeks.

Creeping Substitution in the Haversian Canals

After revascularization and production of new bone on the walls of the Haversian

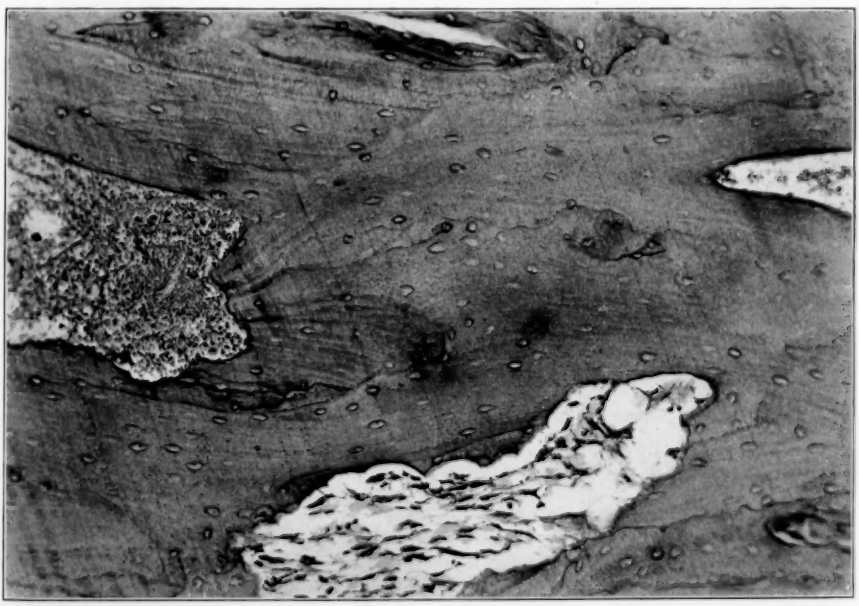

FIG. 13 (× 70)

Revascularization of the Haversian Canals

This field, taken near the endosteal surface of a merthiolate graft of one week's duration, shows revascularization of the Haversian canals by young capillaries, growing in from the host tissues. The Haversian canal at the bottom of the field has been invaded by undifferentiated mesenchymal cells, identical to those seen in the organized hematoma. These cells will eventually produce osteoid tissue.

FIG. 14-A (× 70)

FIG. 14-B (× 70)

Haversian-Canal Proliferation

Fig. 14-A: Haversian canals in a merthiolate graft (five weeks' duration) show proliferation of mesenchymal tissue, osteoid production, and early creeping substitution.

Fig. 14-B: A slightly more advanced degree of the same processes in the Haversian canals of an autogenous graft (five weeks' duration).

canals, as already described, in some unexplained manner there is gradual growth by apposition of this new bone and replacement of the adjacent transplant. This process has been termed creeping substitution. In our sections, active evidence of this process followed revascularization and proliferation of the Haversian canal (Fig. 15) by approximately one week and proceeded to complete replacement of the graft, either autogenous or homogenous.

Ossification of the Osteoid Tissue

The poorly understood process of ossification of osteoid tissue was first evident in

FIG. 15 (× 70)

Creeping Substitution

An excellent example of replacement of a portion of a merthiolate graft (four weeks' duration) by creeping substitution is shown. This gradual invasion and replacement of the dead graft by new bone, derived from the host tissues, occurs at all exposed surfaces,—endosteal, Haversian, and periosteal.

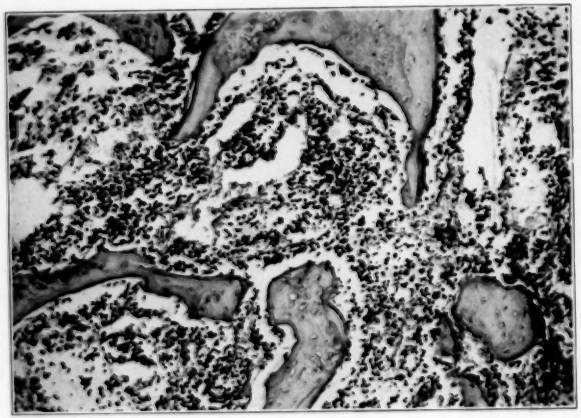

FIG. 16

FIG. 16

Hematopoiesis (× 85)

Shows active hematopoiesis in the intertrabecular spaces of new bone in the marrow cavity of a five-week-old specimen. The exact origin of these cells and their relation to the osteogenetic elements is unknown.

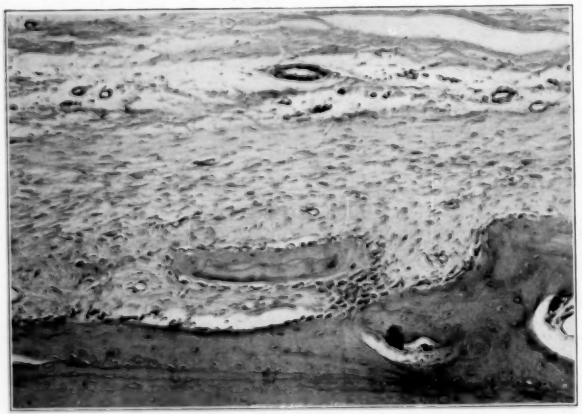

FIG. 17-A

FIGS. 17-A AND 17-B

Periosteal Proliferation (× 85)

A similar degree of proliferation of new bone by the host periosteum over a merthiolate graft (Fig. 17-A) and an autogenous graft (Fig. 17-B) is shown. Both grafts are of ten weeks' duration. Note the apposition of this new bone to the periosteal surface of each graft.

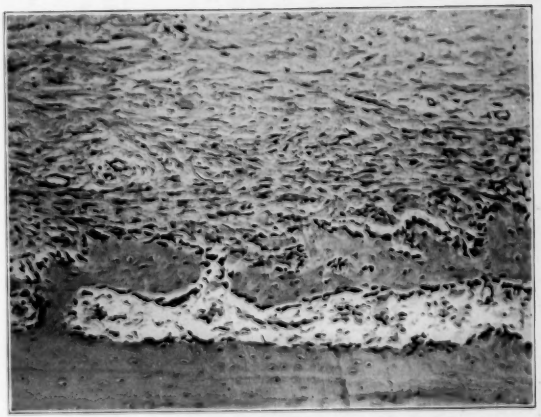

FIG. 17-B

significant degree in all specimens at three weeks. Almost complete ossification of the osteoid was present in all at five weeks. This process continued throughout the succeeding weeks.

Hematopoiesis

In all the grafts studied, hematopoiesis in the intertrabecular spaces of the appositional bone was present at six weeks and became more pronounced in the succeeding weeks. The authors were surprised to see this development so early in the process of bone regeneration. The exact significance of this finding is not understood (Fig. 16).

Remodeling of Bone

Following fixation of the grafts, at which time the newly formed trabeculae are arranged at right angles to the shaft of the bone, a continuous remodeling process occurs which selectively rearranges the trabeculae parallel to the shaft of the bone. This is in accordance with Wolff's law. The inauguration of remodeling became evident at seven weeks in all graft specimens, and continued throughout the succeeding weeks (Figs. 12-A and 12-B).

Periosteal Proliferation

The appearance of subperiosteal proliferation of new bone was late in all grafts, homogenous and autogenous. Technical experimental factors, as noted before, may possibly account for this. However, periosteal-bone proliferation was marked in all specimens at eight weeks and thereafter. The role of periosteal-bone production in remodeling and in mechanical stability is an interesting postulation (Figs. 17-A and 17-B). Our only conclusion concerning the periosteum in these experiments with the inlay type of grafts is that it played but a minor role in the fixation and regeneration of autogenous or homogenous transplants.

CONCLUSIONS

1. There is no evidence from these experiments that any of the bone elements of an autogenous transplant live or retain osteogenetic powers.

2. The authors have demonstrated that, with the inlay type of graft, the fixation and replacement of the graft was totally a function of the host tissue.

3. The fixation and replacement of both autogenous and homogenous bone grafts was accomplished in an identical fashion by appositional growth of the host bone. So-called creeping substitution was but a localized phase in the process of appositional bone growth.

4. Autogenous bone grafts were superior to homogenous bone grafts experimentally only in that the early phase of healing was slightly more rapid and uniform. However, this was not due to viability and regrowth of autogenous grafts; rather it probably represented less host reaction and tissue specificity, which are factors not understood at present.

5. At the end of ten weeks, no microscopic difference could be seen between the autogenous and homogenous grafts; practically complete replacement was present in both.

6. Merthiolate-preserved bone and frozen homogenous bone were indistinguishable experimentally. Boiled homogenous bone, however, proceeded to union much more slowly.

7. The clinical use of homogenous bone grafts is justifiable.

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A CLINICAL ANALYSIS OF 205 CASES OF MALIGNANT BONE TUMOR

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This correlation of pathological material with clinical aspects was suggested when a review of the literature showed that reports of large series of bone tumors were practically non-existent. Furthermore, no series had been presented from a single institution in which only orthopaedic patients were treated, except for a report of 250 cases by Campbell in 1934. Only two other reports bearing any similarity were found.

The first was a report of 175 cases, 148 of which had been diagnosed provisionally as sarcoma of bone. These cases were admitted to the Massachusetts General Hospital and the Collis P. Huntington Memorial Hospital in Boston from 1911 to 1921, and were reported by Greenough, Simmons, and Harmer.

The second study, reported by Christensen, included 1,000 cases submitted to the Registry of Bone Sarcoma and analyzed as to location of tumor, age, and sex. In addition, of course, the classical work of Geschickter and Copeland, first published in 1931 and based largely upon pathological specimens from the Johns Hopkins Hospital, brings up to date the subject of neoplasms of bone. Geschickter and Copeland's classification of bone tumors and their approach to this vast subject have been largely followed in this study.

Many, no doubt, feel that a study such as this is without value, since it only emphasizes the high mortality resulting from malignant tumors. However, malignant tumors of the extremities present a vastly different problem from that presented by malignant tumors elsewhere in the body. In addition, there are cases on record of proved malignant tumors in which occasional cures have been effected by means which, to our knowledge, have not prevented death in the vast majority of cases. A situation such as this offers a challenge in attempting to determine why the rare individual escaped.

The data presented here are not intended to be statistically significant, because of the relatively small number of cases and the great number of variables. The conclusions, therefore, are given from the standpoint of clinical interest and in no way attempt to alter conclusions drawn from other studies of bone tumors.

The methods used in this study were as follows:

1. Only cases of tumor were used, thus eliminating such conditions as Paget's disease, scurvy, rickets, osteitis fibrosa cystica, and dental tumors.

2. Only those cases were used which had been convincingly diagnosed in the Hospital by biopsy and in which adequate follow-up was possible.

3. A count was made of all tumor cases recorded in the office of the Campbell Clinic, and the records of the Pathology Department were studied to determine the number of cases in which biopsy material was available. The tumors were divided into benign and malignant types. The clinical histories of all patients with malignant tumor were studied, and each suitable case was analyzed.

The study of all patients recorded revealed approximately 702 tumor cases in about 80,000 records or 0.875 per cent. Of these 702 tumors, 287 were considered benign and 415 malignant; 437 patients were admitted to the Hospital for treatment or diagnosis. Among this group, 205 had malignant tumors and 232 had benign tumors. The benign tumors included 150 osteochondromata, 42 giant-cell tumors, 27 enchondromata, and 13 osteoid osteomata.

The rest of this paper will be devoted to the detailed study of the 415 cases of malignant tumor. Of this number, 152 or 36.6 per cent. were osteogenic sarcomata. Included are the primary and secondary chondromyxosarcomata, the sclerosing and the osteolytic

types of osteogenic sarcomata, and the so-called chondroblastic sarcoma. Of almost equal incidence were the metastatic malignant tumors, of which there were 163 or 39.3 per cent. The next most common was Ewing's tumor with 65 cases or 15.7 per cent. Fibrosarcomata followed with 24 or 5.8 per cent. The most rare was multiple myeloma with 11 cases or 2.6 per cent.

The patients in the malignant group were first studied from the standpoint of age; Figure 1 shows the comparison by decades up to seventy years of age. The highest incidence occurred between the ages of eleven and twenty years and the next highest from

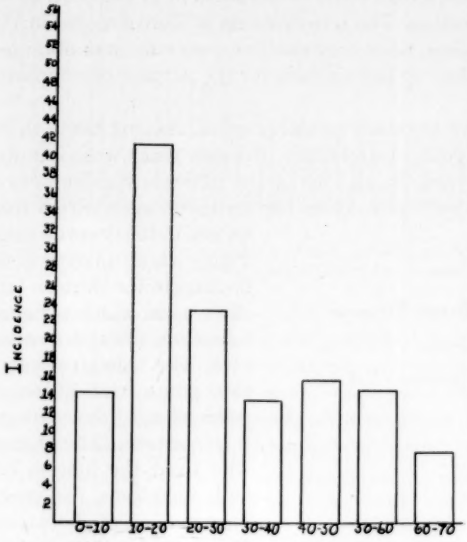

Fig. 1

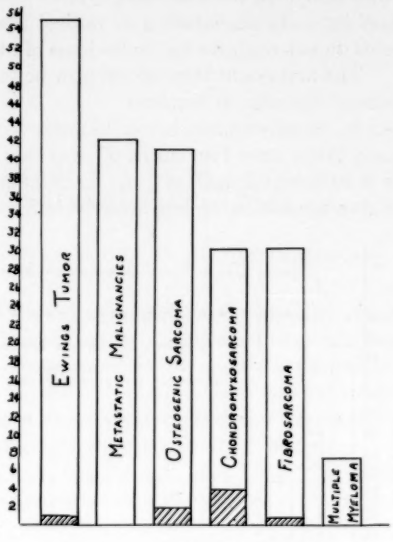

Fig. 2

Fig. 1: Incidence of malignant tumors according to ten-year age groups.
Fig. 2: Numerical analysis of malignant tumors. Shaded sections show five-year cures.

twenty-one to thirty years. This was to be expected, since these groups include the vast majority of Ewing's tumors and osteogenic sarcomata. Ewing's tumor, osteogenic sarcoma, and one case of fibrosarcoma made up the tumors in patients under ten years of age. The groups from thirty-one to forty years and from forty-one to fifty years were made up about equally of these three tumors. The groups from fifty-one to sixty years and from sixty-one to seventy years were made up almost entirely of metastatic tumors and multiple myelomata. Thus it would appear that malignant bone tumors are most apt to develop between the ages of eleven and thirty and less apt to develop between the ages of thirty-one and forty years. In any other ten-year period, the chances are remote.

A comparison of the various tumors (Fig. 2) shows that Ewing's tumor was the most common, with fifty-five cases. Next was metastatic malignant tumor, forty-two cases; osteogenic sarcoma, forty-one; chondromyxosarcoma, thirty; fibrosarcoma, thirty; and multiple myeloma, seven. If osteogenic sarcoma and chondromyxosarcoma had been considered together, as they probably should have been, they would have totaled seventy-one, far more than Ewing's tumor or metastatic malignant tumor. Chondroblastic sarcoma has been omitted from the classification. Tumors so diagnosed have been included as osteogenic sarcoma, since there is considerable argument about this tumor as an entity and the general agreement is that it does fit into the osteogenic group.

The number of five-year cures in patients who are alive at the present time are shown

in Figure 2. For Ewing's tumor the figures do not coincide with those of Hamilton, who reviewed these cases up to 1939. This discrepancy is accounted for by the fact that one of the patients he reported as living after five years has since died of metastases. In his conclusions he warned that the prognosis should be guarded even after five years.

As might be expected, no cures were effected in the cases of metastatic tumors or multiple myeloma.

Two five-year cures occurred in cases of osteogenic sarcoma and four in chondromyxosarcoma. These figures do not agree with those of Geschickter and Copeland, who found that with the sclerosing type of lesion, a cure could be obtained in 21 per cent. of the cases by early amputation or radical resection. The observations in fibrosarcoma in this series do not conform to the findings of others, since only one five-year cure was obtained.

The malignant tumors will now be taken up individually for the purpose of comparing some of the clinical features.

In *chondromyxosarcoma,* biopsies were obtained in thirty cases. Among these thirty cases, there were four cures of over five years. In addition, thirteen cases were followed for a sufficient length of time to be analyzed. In all four of the patients who had cures, thigh amputation or hip disarticulation had been done. The patients' ages varied from sixteen to thirty-seven years. Figure 3 is an analysis of the findings in the thirteen fatal cases upon which adequate follow-up data are available. The oldest patient in this group was fifty-eight years of age, the youngest was thirteen. The patient who lived the longest had had symptoms for twelve months before treatment. He was thirty years of age and his tumor was located in the lower portion of the femur. Treatment consisted of a high-thigh amputation and Coley's toxins. The patient who lived the shortest time (five months) had had symptoms for two months before treatment. His lesion was in the upper portion of the femur, and treatment consisted of roentgenotherapy and Coley's toxins. The only other case in this group treated by roentgenotherapy without amputation is shown as the second from the left (Fig. 3). She was forty-two years of age and had had symptoms for forty-eight months before treatment was begun. She lived only four months after this treatment. In the remainder of the cases, amputation was done as soon as the diagnosis had been established, with the results indicated. There appears to be no fixed relationship of symptoms before treatment to length of life. The average duration of life after the onset of symptoms was 25.3 months; the average duration of symptoms before treatment was 9.4 months.

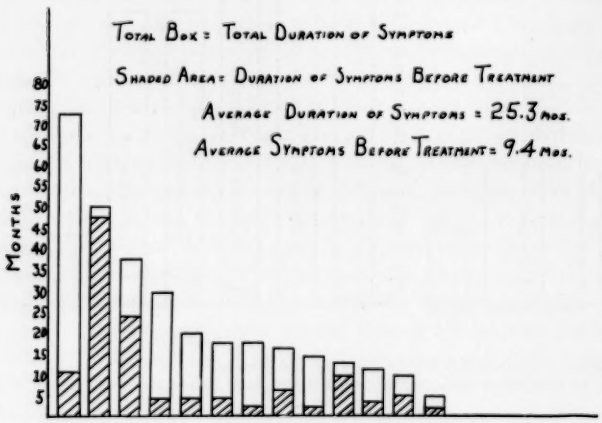

FIG. 3

Analysis of cases of chondromyxosarcoma, showing relationship of length of life after onset of symptoms to duration of symptoms before treatment.

Osteogenic sarcomata, including both the osteolytic and the sclerosing type and chondroblastic osteogenic sarcomata, constituted the second largest group of primary malignant bone tumors. In this group there were two cures, both in lesions of the sclerosing type. One was in a seventeen-year-old girl whose lesion was in the mandible. The other was in a sixteen-year-old boy whose lesion was in the upper portion of the tibia. Both pa-

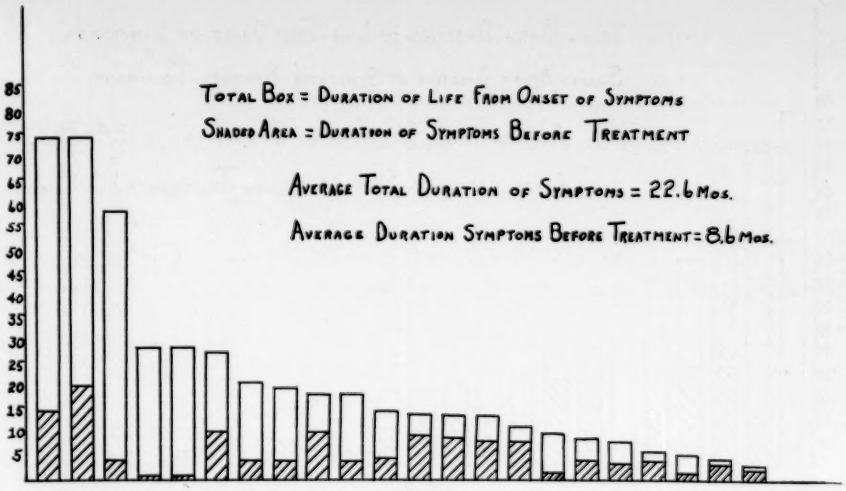

FIG. 4

Analysis of cases of osteogenic sarcoma, showing relationship of length of life after onset of symptoms (in months) to duration of symptoms before treatment.

tients had amputation, followed by irradiation. Data concerning the cases in which death occurred following treatment are presented in Figure 4. Here again, a number of cases had to be deleted because of incomplete follow-up or because the treatment was too recent. Biopsies were done in forty-one of these cases of osteogenic sarcoma, and twenty-two of them were suitable for this study. The oldest patient was sixty-seven years of age and the youngest was nine years. Three patients survived longer than is usually expected.

The first patient was a girl, twenty-one years old, who had a lesion in the upper portion of the femur. Her symptoms had been present for fifteen months before treatment; sixty months after treatment was begun, she died of metastasis. This case is most unusual, because the treatment had consisted of resection of the tumor mass only.

The second patient also lived a total of seventy-five months; his initial lesions were in the second and third lumbar vertebrae. His symptoms were of twenty-one months' duration before treatment by roentgenotherapy alone.

The third patient was a woman, forty-eight years old, whose primary lesion was in the skull. She had had symptoms for four months before the institution of deep roentgenotherapy. Her total duration of life was fifty-nine months after the onset of symptoms.

The remainder of the patients survived for just about the expected length of time. The tumors were all in the lower extremities, except for two in the humerus. There appears to be no relationship between the duration of symptoms before treatment and the length of life after treatment.

The first three cases in this group do not fit into the usual picture of the disease. In the first place, all three of the tumors appeared at unusual sites,—namely, the skull, the lumbar vertebrae, and the upper portion of the femur. The aberrant location of the lesions also accounted for the type of treatment which had to be given. These findings would suggest that perhaps such treatment might be the choice in other similar cases. However, a study of the other cases in this group indicates that the patient with the shortest duration of life after the onset of symptoms had a lesion in the upper portion of the femur, and treatment was almost identical with that of a patient who died one month after therapy had been instituted.

The average duration of life after the onset of symptoms in this group was 22.6 months; the average duration of symptoms before treatment was begun was 8.6 months.

Ewing's tumors constitute the largest group of primary malignant tumors of bone in this series. The total number of Ewing's tumors in the files is sixty-five. Of this number,

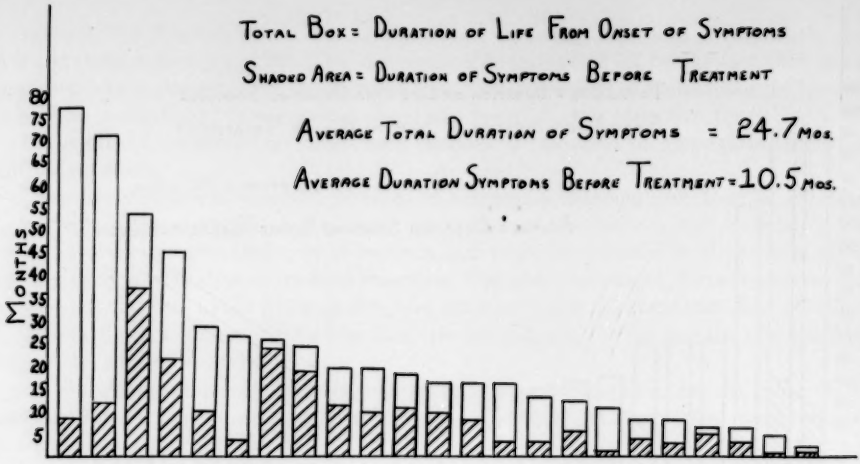

FIG. 5

Analysis of cases of Ewing's tumor treated by roentgenotherapy only, showing relationship of length of life after onset of symptoms to duration of symptoms before treatment.

forty could be included in this analysis; only one patient is living. He was twenty-one years of age when first seen and he had had symptoms for four months. His primary lesion was in the mid-tibia and treatment consisted of curettage, roentgenotherapy, and Coley's toxins. He has lived for eighteen years following that treatment. The question of a mistaken diagnosis might logically arise in a case such as this. However, two separate explorations of the tumor were made and the diagnosis of the sections was confirmed by the Bone Registry.

For clinical comparison, these tumors have been divided into two groups. The first group includes those patients who were treated by roentgenotherapy, either alone or combined with Coley's toxins. The second group includes those treated by amputation and roentgenotherapy.

In the first group it is evident (Fig. 5) that four patients lived longer than the usual expectancy.

The first of these was a woman, forty-two years old, whose primary lesion was in the upper portion of the humerus. Her symptoms had persisted for eight months before treatment by roentgenotherapy alone. Following this treatment, she lived for sixty-nine months.

The second patient was a male, twenty-four years old, whose primary lesions were in the ninth, tenth, and eleventh ribs. He had had symptoms for twelve months previous to treatment by roentgenotherapy. Following this treatment, he lived for sixty months.

The third patient was a seventeen-year-old boy whose primary lesion was in the mandible. He had had symptoms for thirty-six months previous to roentgenotherapy, after which he lived for seventeen months.

The fourth patient was an eleven-year-old boy with a lesion in the upper portion of the femur. His symptoms had persisted for twenty-two months prior to roentgenotherapy, after which he lived for twenty-three months.

In the remainder of the cases in this group, amputation was not done because of inaccessibility of the lesion. This situation is reflected in the short duration of life after the first symptoms, the average being 24.7 months. The average duration of symptoms before treatment was 10.5 months. The observation previously made that, in patients in whom the duration of symptoms has been longer than average before treatment, the duration of life after treatment is longer, is not borne out in this group of tumors.

Figure 6 depicts the course of those patients with Ewing's tumor who were treated by amputation and roentgen ray. These patients, as a group, fared much better than those who were treated by roentgen ray only. The average duration of life after the

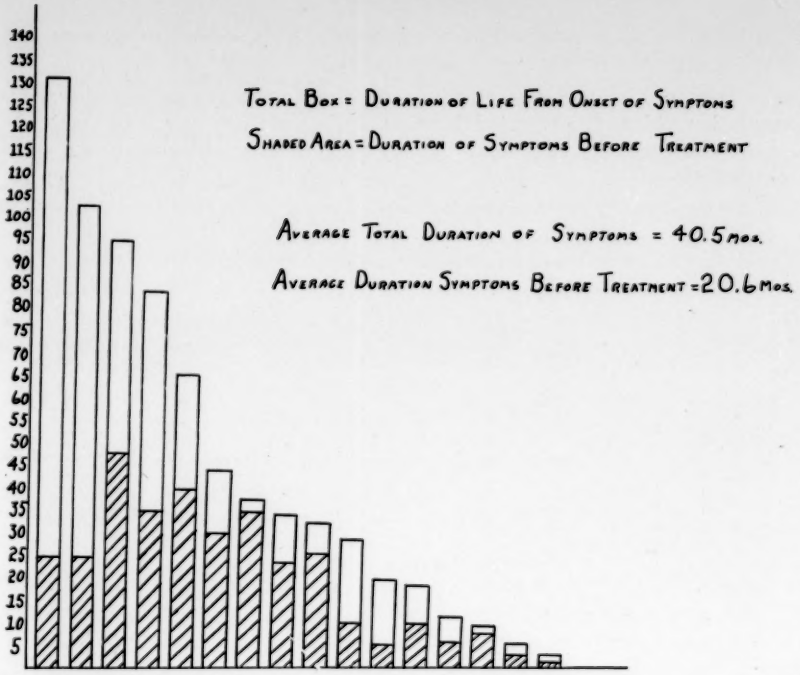

FIG. 6

Analysis of cases of Ewing's tumor treated by amputation plus roentgenotherapy, showing relationship of length of life after onset of symptoms to duration of symptoms before treatment.

first symptoms was 40.5 months, compared with 24.7 months in the first group. The average duration of symptoms before treatment was 20.6 months, compared with 10.5 months in the first group.

A comparison of the two groups shows that a longer duration of symptoms before treatment points to longer expectancy of life after treatment. In the second group, six patients survived over forty months after the initial symptoms, and only three patients lived less than one year.

The first patient in this group was a twelve-year-old girl. A lesion in the lower portion of the tibia had produced symptoms for twenty-four months before she had a low-thigh amputation, followed by the administration of Coley's toxins and roentgenotherapy. After treatment she lived for 107 months, or a total of 131 months after onset of symptoms.

The second patient was a twelve-year-old boy. He had a lesion in the upper portion of the tibia which had produced symptoms for twenty-four months, after which he was treated by amputation, roentgenotherapy, and Coley's toxins. Following treatment he lived for seventy-nine months, making a total of 103 months of life after the onset of symptoms.

The third patient, a woman of fifty-one years, had had a lesion in the upper portion of the tibia for forty-eight months before treatment. Treatment consisted of resection of the tumor and roentgenotherapy, after which the patient lived for forty-seven months. This was a total of ninety-five months of life after her first symptoms.

The fourth patient was a thirty-year-old woman, who had had symptoms for thirty-six months as a result of a lesion in the mid-femur. She then had a hip disarticulation, followed by irradiation therapy. She lived for forty-eight months thereafter, or a total of eighty-four months of life after her first symptoms.

The fifth patient was a twenty-year-old woman with a lesion in the upper portion of her humerus. She had had symptoms for thirty-six months before treatment, which consisted of resection of the tumor and the administration of Coley's toxins. She lived for twenty-seven months after treatment, or a total of sixty-three months of life after the onset of symptoms.

The sixth patient was a four-year-old girl, who had had an upper tibial lesion and symptoms for thirty

months. She had a mid-thigh amputation, followed by roentgenotherapy, and she lived for fourteen months. Her total period of life after the onset of symptoms was forty-four months.

These cases, when compared with the group which had only roentgenotherapy, show that amputation adds to the expected duration of life. This, however, is not an invariable outcome, for a few cases will terminate rapidly in spite of radical amputation and thorough roentgenotherapy.

Multiple myelomata were the least common of all the malignant lesions in this series. As was to be expected, there were no cures. Seven cases were recorded; six had complete data. One case was too recent to be considered. All of the patients were between fifty and sixty years of age. The average total duration of life after onset of symptoms was 18.3 months; the average duration of symptoms before diagnosis was 7.2 months (Fig. 7). No relationship was noted between duration of symptoms before diagnosis and duration

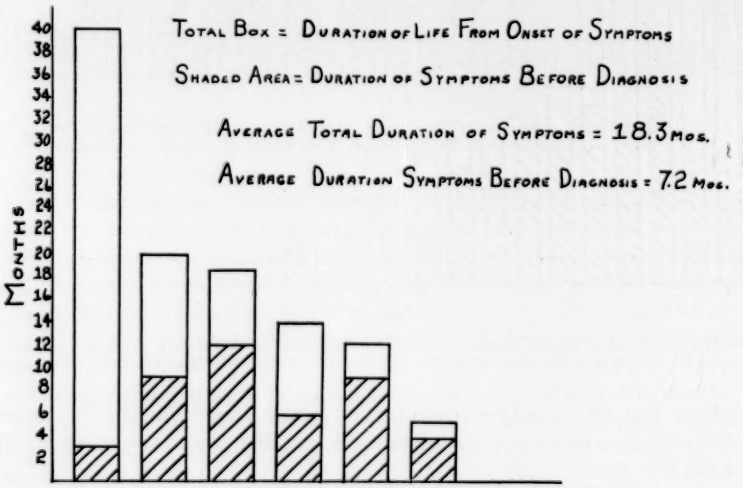

FIG. 7

Analysis of cases of multiple myeloma, showing relationship of length of life after onset of symptoms to duration of symptoms before diagnosis.

of life afterward, nor could any relationship be established between the multiplicity of lesions and life expectancy.

In treating the *metastatic malignant tumors*, many obstacles were encountered. Most patients with metastatic cancer were unaware of the presence of a primary lesion; consequently, it is practically impossible to classify these cases as to their origin. Without such knowledge, the study really has no value, since all we can hope to accomplish is to forecast possible bone metastasis of soft-tissue tumors. Unfortunately, these patients leave the hospital after diagnosis and many of them are not heard from again. When they die at home, an autopsy is not performed and, unless the tumor forms some obvious pattern, as in hypernephroma, the true diagnosis is never known.

Of the forty-two patients with metastatic cancers (Fig. 8), nineteen had complete follow-up studies. The average duration of life after the onset of symptoms was 13.7 months; the average duration of symptoms before diagnosis was 8.1 months.

Although thirty cases of *fibrosarcoma* were recorded in the files, it was found that many of them were actually soft-tissue tumors without bone involvement, so that the number for analysis was reduced to eleven. There was one fifteen-year cure in which the primary lesion had been in the calcaneus. The man's symptoms had lasted for three years

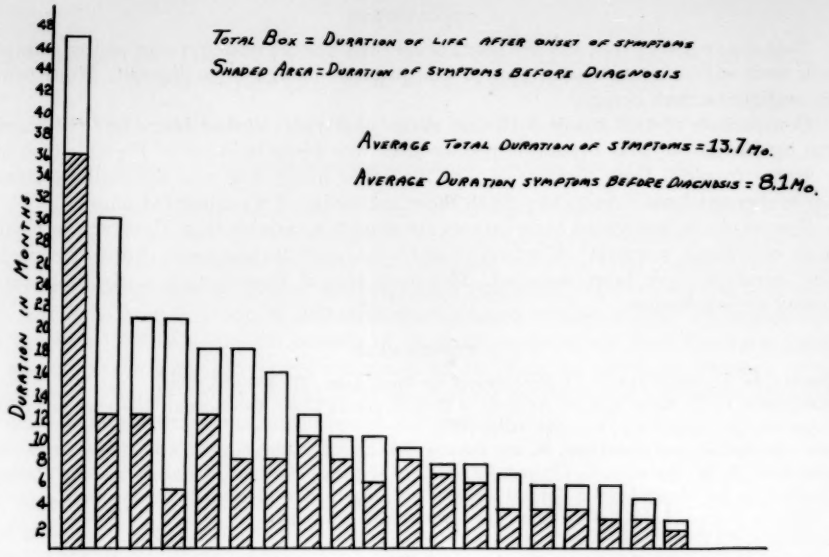

Fig. 8

Analysis of cases of metastatic malignant tumors, showing relationship of length of life after onset of symptoms to duration of symptoms before diagnosis.

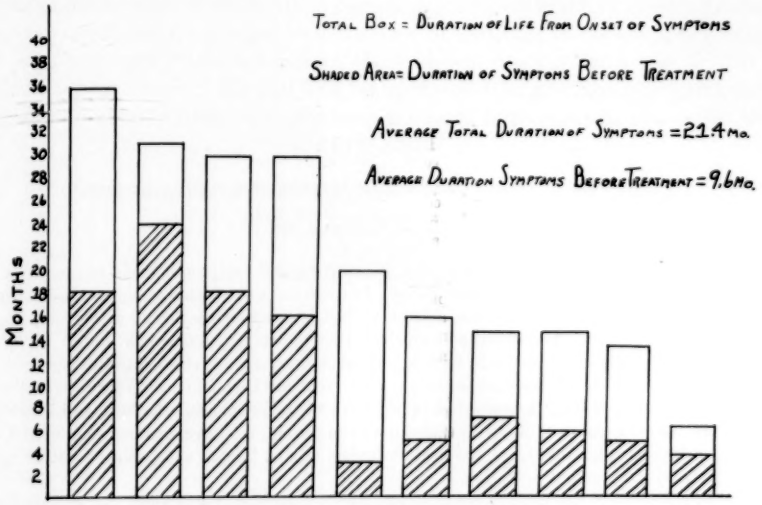

FIG. 9

Analysis of cases of fibrosarcoma, showing relationship of length of life after onset of symptoms to duration of symptoms before treatment.

previous to a below-the-knee amputation. The oldest patient in this group was fifty-eight years, the youngest seven years of age.

Study of the ten cases suitable for analysis (Fig. 9) showed a longer duration of symptoms, both before treatment and totally, than in any of the other groups. In general, these tumors responded poorly to roentgen-ray treatment.

CONCLUSIONS

This study shows that 0.8 per cent. of all orthopaedic patients seen at the Campbell Clinic were suffering from some sort of bone tumor, benign or malignant. More tumors were malignant than benign.

Comparison of this study with one made nine years earlier bears out the warning given by Hamilton, that favorable results after five years in cases of Ewing's tumor do not assure freedom from metastasis. On the other hand, five-year favorable results in other malignant bone tumors are much more indicative of a permanent cure.

The results in malignant bone tumors are almost invariably bad. However, in Ewing's tumor, osteogenic sarcoma, chondromyxosarcoma, and fibrosarcoma, cures of over five-years' duration have been recorded. The most logical treatment is early amputation, followed by irradiation.

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DISCUSSION

Myelography in the Diagnosis of Intervertebral-Disc Lesions

(*Continued from page 266*)

condition was not recognized. I see no reason why, if an orthopaedic surgeon is going to remove a disc and encounters a tumor, he shouldn't remove that as well. In three cases in which a malignant lesion in the lumbosacral spine was causing intractable pain, I have excised as much of the tumor as I could, simply as a palliative measure. The pain was relieved and we think that the surgery was worth while.

I do not believe that the ligamentum flavum presses on a normal nerve root and causes pain. I doubt if it can be thickened that much because, unless the nerve root has been lifted up from the front and is displaced backward, there is usually a wide space between it and the ligamentum flavum (and I include in my observation the lateral expansion of the ligament over the canal). We have had one case with a posterior defect due to a fractured lamina; there was a piece broken off the lamina and pushed forward against the nerve root. This was removed at operation.

I have not changed my opinion as a result of Dr. Barr's discussion. I still think that one should operate in the typical case without subjecting the patient to a myelogram. Myelography should be used only in cases in which the diagnosis or the location of the lesion is not sufficiently clear to enable the surgeon to operate with confidence. We operate for the relief of pain, and we think that direct inspection and instrumental palpation of the disc offer better evidence of a pathological condition than does a myelogram.

Dr. James W. Toumey (closing): I should like to thank Dr. Barr for his discussion; I am in hearty accord with the opinions he expressed. The most important reason for myelography in suspected disc lesions is for aid in exact diagnosis. We have seen that the myelogram is the most valuable means of differentiating between disc and tumor lesions. Additionally, the myelogram usually gives significant information as to the size and position of the disc.

AN ANALYSIS OF FIFTY-NINE CASES OF OSTEOGENIC SARCOMA WITH SURVIVAL FOR FIVE YEARS OR MORE

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Those interested in the outcome of cases of osteogenic sarcoma (including chondrosarcoma and fibrosarcoma) have been unable to explain why some patients have survived for five or more years, while the majority have followed the usual fatal course. Accordingly, a study was undertaken at Memorial Hospital of fifty-nine five-year survivals of osteogenic sarcoma, from a group of 252 determinate cases treated during the period from 1917 through 1943. The clinical records of these fifty-nine cases, their roentgenograms, and microscopic reports have been examined in an effort to ascertain whether or not certain types offered a better prognosis. It was further considered of interest to determine the methods of treatment employed in the successful group.

In a recent publication [2], an analysis was presented of results in osteogenic sarcoma from 1917 through 1940, covering a determinate group of 265 cases, of which 58 or 21.9 per cent. were regarded as successes. As a result of further scrutiny, however, some of the so-called successes, due to a revision of diagnosis, have been eliminated; therefore, while the present study covers three additional years, only one more five-year survival is recorded.

The histological type of sarcoma encountered in this group of fifty-nine cases is shown in Table I. It reveals the fact, already suspected, that two-thirds of these cases were of the fibrosarcoma or chondrosarcoma type. Of the latter, histological examination showed the majority were of relatively low-grade malignancy and had arisen as secondary chondromyxosarcomata from a pre-existing area of cartilage in an abnormal situation. Only 27 per cent. were diagnosed merely as osteogenic sarcoma, and only 3.4 per cent. were called "telangiectatic". We had long realized that telangiectatic osteogenic sarcoma was a most unfavorable form; the roentgenograms in both cases in this series showed

TABLE I

TYPE OF SARCOMA IN FIFTY-NINE CASES WITHOUT EVIDENCE OF DISEASE FOR FIVE OR MORE YEARS

1919 to 1948

Pathological Type		No. of Cases	Per cent.
"Osteogenic sarcoma"		16	27.2
Chondrosarcoma		20	33.8
Spindle-cell sarcoma		20	33.8
Medullary	14 (23.8%)		
Periosteal	3 (5.0%)		
Combined	3 (5.0%)		
Telangiectatic		2	3.4
Unclassified		1	1.8
Total		59	100.0

the lesion to be osteolytic rather than osteoplastic, and the treatment in both was amputation combined with preoperative roentgen therapy and toxins.

TREATMENT OF PATIENTS SURVIVING FIVE YEARS

It seemed important to consider the treatment of these cases, in an attempt to determine what part the therapy might have played in the outcome. In the sixteen cases

TABLE II

TREATMENT OF SIXTEEN CASES OF "OSTEOGENIC SARCOMA"

Treatment	No. of Cases	Total
Surgery		16
A. Radical (loss of limb)	15	
Combined with toxins	1	
Combined with roentgen therapy	4	
Combined with toxins and roentgen therapy	5	
Surgery alone	5	
B. Conservative	1	
Surgery alone	1	
Roentgenographic Interpretation		
Films not available		6
Films available		10
Osteoplastic	6	
Osteolytic	3	
Equivocal	1	

classed as "osteogenic sarcoma" without further qualification, major amputation was performed in fifteen and partial amputation (of a hand) in the remaining case. The additional treatment in ten of the sixteen cases is shown in Table II. It is exceedingly difficult to determine the role, if any, played by the toxins, or by roentgen therapy or radium-pack treatment in the survival of these cases.

Of the twenty cases of chondrosarcoma, one was treated by toxins and irradiation. This was a case in which the lesion was in a rib (Case 1). All of the other patients had surgery; fourteen had major amputations and five had conservative surgical measures (Table III). The point that deserves emphasis, and one which has been brought out in previous papers [1, 3], is that amputation may sometimes be avoided in carefully selected cases of low-grade chondrosarcoma, while such an opportunity is afforded very rarely in osteogenic sarcoma.

Of the twenty cases of "spindle-cell" osteogenic sarcoma (fibrosarcoma), fourteen were medullary, three were periosteal, and three combined the features of both. Treatment involved radical surgery (amputation) in eighteen cases; two patients received only

TABLE III

TREATMENT OF TWENTY CASES OF CHONDROSARCOMA

Treatment	No. of Cases	Total
Surgery		
A. Radical (loss of limb)		14
Combined with toxins	5	
Combined with roentgen therapy	5	
Combined with toxins and roentgen therapy	4	
B. Conservative		5
Combined with toxins	0	
Combined with roentgen therapy	1	
Combined with toxins and roentgen therapy	1	
Surgery alone	3	
Irradiation and toxins		1
Irradiation alone		0
Roentgenographic Interpretation		
Films not available		4
Films available		16
Osteoplastic	9	
Osteolytic	7	

TABLE IV

TREATMENT OF TWENTY CASES OF SPINDLE-CELL OSTEOGENIC SARCOMA

Treatment	No. of Cases	Total
Medullary		14
Radical surgery (loss of limb)	13	
Combined with toxins	1	
Combined with roentgen therapy	3	
Combined with toxins and roentgen therapy	6	
Surgery alone	3	
Roentgen therapy alone	1	
Toxins and roentgen therapy	0	
Periosteal		3
Radical surgery	2	
Combined with roentgen therapy	2	
Radium and roentgen therapy only	1	
Combined		3
Radical surgery	3	
Combined with toxins	1	
Combined with toxins and roentgen therapy	2	
Total		20

irradiation. However, most of those treated by amputation also had irradiation, either alone or combined with toxins (Table IV). The details of treatment will be given for the two cases which had irradiation alone (Cases 2 and 3).

The single case which the pathologist listed as "unclassified" was treated by amputation alone. The tumor was regarded as a form of osteogenic sarcoma.

The authors were unable to determine any convincing difference between the prognosis of the fibrosarcomata that were of periosteal origin and those of medullary origin; the same is true for those which were osteolytic, as compared with those having osteoplastic properties. Of course, many osteogenic sarcomata show both features in the same tumor.

CASE 1. K. F., a woman, aged twenty-nine, was first seen at Memorial Hospital in December 1922, with a history of having had a biopsy performed on her right seventh rib, six months previously. Ewing reported this as chondrosarcoma, and the patient received nine injections of Coley's toxins and about 20,000 millicurie hours of radium-emanation pack at a distance of ten centimeters. It is impossible to determine the total radiation given, because she had had roentgen therapy in St. Louis some months before reporting at Memorial Hospital. The case was accepted as one of osteogenic sarcoma by the Registry of Bone Sarcoma and the woman was known to be well in 1948, twenty-six years later.

CASE 2. E. S. G., a man, fifty-nine years old, was admitted to Memorial Hospital on January 27, 1933. The microscopic diagnosis on the basis of a punch biopsy from the ilium was spindle-cell and giant-cell sarcoma. The patient was treated with high-voltage roentgen rays in two cycles, at an estimated depth dose of 4,770 r. Unfortunately, a large radiation ulceration of the skin in the region of the right groin developed six years later and, while awaiting hospitalization for treatment of this, the patient committed suicide.

CASE 3. G. R., a woman, aged thirty-six, was admitted on May 23, 1930. The diagnosis was periosteal fibrosarcoma of the humerus, reported as locally malignant and non-metastasizing. The patient received exposures of the radium-element pack at a distance of six centimeters, a total of 20,000 milligram hours to each of two portals. In addition, radium needles were implanted into the tumor for a dosage of 2,600 milligram hours. Recently Helen Q. Woodard estimated that this resulted in a tissue dose equivalent to 5,000 r. The patient survived for fourteen years and four months, and died of a breast carcinoma with metastases.

SUMMARY

As a result of this survey, the following observations have been made:

1. It is worth while to attempt to separate the more commonly encountered varieties

of osteogenic sarcoma (as used in its broadest sense), because the prognosis is distinctly better in some types than in others. The tendency for fibrosarcoma and chondrosarcoma (mainly the low-grade "secondary" chondromyxosarcomata) to metastasize later than "osteogenic sarcoma" is a clinical impression which this study would seem to confirm. The authors believe that the microscopic appearance of tissue taken from the tumor affords the most reliable index of the rapidity of the growth and its tendency to early or late metastasis. Exceptions are, of course, not unusual. This series includes some cases in which a favorable outcome was considered highly unlikely; and, on the other hand, in cases deemed of slow growth with likelihood of survival, the patients have died within five years from pulmonary metastasis.

2. The greatest number of five-year survivals were treated surgically. Of fifty-seven patients with involvement of the long bones, fifty-one had amputation or disarticulation and six had conservative surgery; lesions in five of the six were chondrosarcomata. Two cases of fibrosarcoma were treated by irradiation only. In another case, with chondrosarcoma of the rib, the patient received irradiation together with toxins.

3. The part played by irradiation in survival is not easy to estimate. Most of the cases in which it was used were treated in the period prior to 1940, when a high proportion of patients having amputation received preoperative roentgen therapy. However, in the past five years preoperative therapy has virtually been abandoned, and it will soon be possible to make a comparative study of sizable groups treated by amputation, with or without preliminary radiation therapy.

4. Routine postoperative toxin treatment was abandoned several years ago. The senior author became convinced that its use for cases of osteogenic sarcoma could not be justified by any statistical evidence of improvement in the five-year survival rate.

5. There were no five-year survivals in this series of osteogenic sarcoma, including fibrosarcoma and chondrosarcoma, where the lesion was located in the proximal end of the femur.

6. To support the contention that five years is not a sufficiently long period upon which to base end results in this disease, the authors found that five of the fifty-nine patients or 8.5 per cent. died of sarcoma after surviving for five years. Of these, two succumbed after a period of between five and six years, two between six and seven years, and one after fourteen years. Another patient is still ambulatory fifteen years after amputation, but has a large pulmonary metastasis; in this instance the tumor was a low-grade chondrosarcoma of the distal end of the femur. However, one may conclude that, if a patient with osteogenic sarcoma survives for five years, his chances of escaping further evidences of this disease are approximately twelve to one.

7. Lobectomy for pulmonary metastasis, discovered late in the course of the disease, was carried out in two of the cases in this series. One patient died eighteen months after the lobectomy, and sixty-one months after amputation. The other is living and free from evidence of disease, three years after the lobectomy and eight years after amputation. The tumors in these cases were both low-grade chondrosarcomata.

It is hoped that a report of this list of fifty-nine carefully authenticated cases of osteogenic sarcoma in its various forms may help to dispel the attitude, which seems all too prevalent, that this disease is uniformly fatal and that therapy is of so little value as to call for no great effort to reach an early diagnosis and to institute prompt appropriate treatment.

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FIBROUS DYSPLASIA OF BONE *

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Translated by John G. Kuhns, M.D., Boston, Massachusetts

In an attempt to elucidate the complex problem of the true histogenetic nature of a certain group of osseous lesions, recently separated and differentiated from generalized osteitis fibrosa of Recklinghausen (hyperparathyroidism), we are presenting these data, resulting from a study of a series of cases showing fibrous dysplasia of bone. The nomenclature differs widely, and among the names given to this condition are: "osteitis fibrosa", "osteodystrophia fibrosa", "fibrous dysplasia" (monostotic or polyostotic), as described by Jaffe and Lichtenstein.

MATERIAL AND TECHNIQUE

Our investigations have been carried out on material which consisted chiefly of bone lesions in a group of patients having fibrous dysplasia. These were subdivided in the following manner:

1. Monostotic form
   - A. With one lesion, solitary ..... 10 cases
   - B. With several foci, at times confluent ..... 3 cases
2. Polyostotic form, limited to a few bones (diostotic and monomelic) .. 1 case
3. Polyostotic form, involving many bones
   - A. Without extra-osseous symptoms ..... 2 cases
   - B. With cutaneous pigmentation and precocious puberty (Albright's syndrome) ..... 1 case **

In addition, there were studied one case of neurinoma with osseous lesions, two medullary fibromata and two periosteal fibromata, and ten cases of bony xanthomatosis, some solitary and some multiple, but without craniohypophyseal lesions. These ten we classified as histiocytic xanthomatous granulomata [12].

In some of these cases the material was from surgical biopsies, but in most of them a large amount of tissue was removed by curettage and resection in order to eradicate the disease.

In this work the writers sought especially to verify the concepts promulgated by Thannhauser in his work on neurofibromatosis (von Recklinghausen) and localized and disseminated osteitis fibrosa cystica (von Recklinghausen), which he regarded as related entities. Therefore, in almost all cases, we employed, in addition to the usual staining techniques with both paraffin and celloidin sections, all of the variations of Rio Hortega, especially those designed for mesenchymal and nerve elements, and those of Bielschowsky and of Ramón and Cajal for frozen sections. By utilizing the stains for lipoid substances, we attempted to clarify the existing relationship between xanthomatosis and fibrous dysplasia of bone.

PATHOLOGICAL ANATOMICAL STUDY

1. *Monostotic Form*

Thirteen cases were studied, ten with a single or solitary lesion; in four, the lesion was localized in the femur; in two, in the rib; in three, in the tibia; and in one, in the mandible. In three of the four cases showing involvement of the femur, the lesions were located in the upper portion,—that is, the neck and trochanteric region.

* This work was performed in the Rio Hortega Laboratory of Histopathological Investigation, Roux Foundation (M. Polak), the Department of Orthopaedic Surgery of the Faculty of Medicine of Buenos Aires (Prof. J. Valls), and the Laboratory of Pathology (F. Schajowicz).

** Contributed by Dr. Reforzo Membrives.

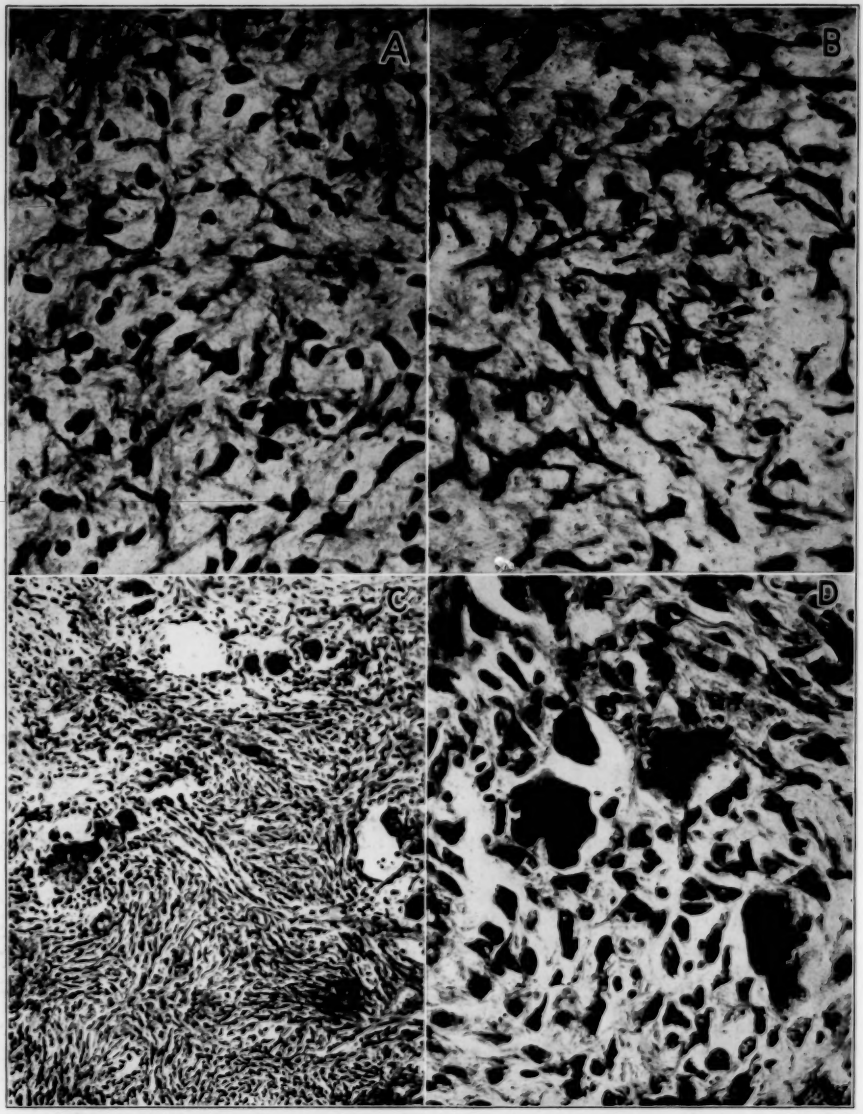

FIG. 1

A and *B:* Photomicrographs showing the mesenchymal elements to be isolated and loosely anastomosing.

C: Mesenchymal elements are compact and enmeshed. A few giant cells are seen in relation to the blood sinuses.

D: Under higher magnification, the giant cells seen in *C* demonstrate their morphological characteristics.

In three cases there were several foci, usually grouped together, sometimes confluent, and always located in the upper end of the femur. The ages of these patients varied between nine and forty years, the average being twenty-five years. Eight patients were males and five were females.

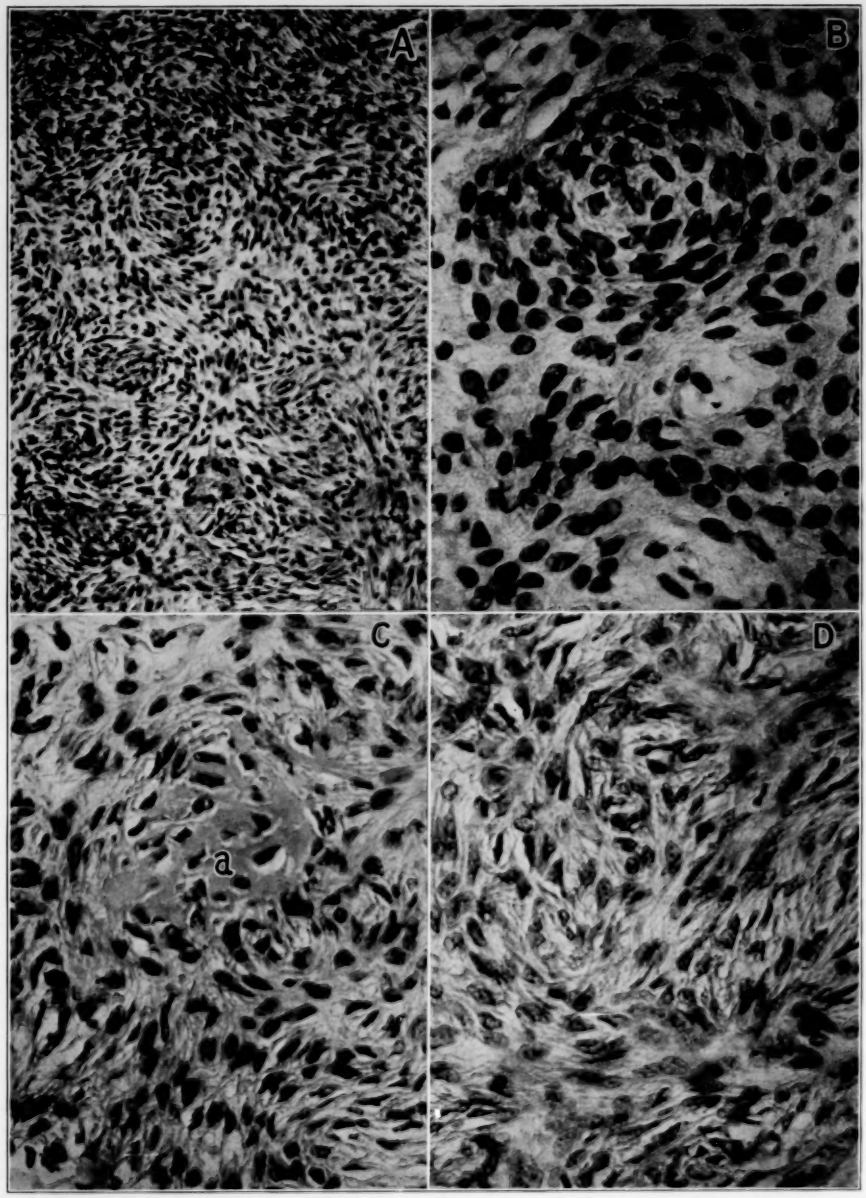

FIG. 2

A: Photomicrograph showing cellular elements arranged in whorls.
B: The whorls under higher magnification.
C and *D:* Photomicrographs showing whorls of connective tissue. A single newly formed trabecula may be seen in *C*, *a*.

On macroscopic examination, the cortical bone was found to be much thinned and a little distended, and the medullary cavity was occupied by grayish-white fibrous tissue,

in some cases with small cystic cavities, usually about the size of a hazelnut. The grayish-white fibrous tissue gave a bonelike resistance to light touch. Alternating with this tissue were other areas which were reddish in color, due to hemorrhage.

We have never observed zones of a cartilaginous aspect or yellowish areas of xanthomatous type on macroscopic examination of our operative specimens.

The microscopic examination of the tissue, prepared with the usual stains, gave the histological picture recognized as that of substitution of the osseous medulla by connective tissue, and in part was quite rich in cells of the fibroblastic type, either young or mature. In other zones the cells were more sparse with denser connective tissue, at times hyalinized. There were zones of a myxoid aspect and others which seemed to correspond to undifferentiated mesenchymal elements. The vascularization was very profuse in these zones and in those of greater cellular abundance, consisting generally of blood capillaries with endothelial walls often much dilated and hyperaemic.

Within the connective tissue many newly formed bone trabeculae were seen. They were of irregular size, form, and distribution, and for the most part were osteoid in nature and often partially or completely calcified. In the margin of these trabeculae there were often rows of osteoblasts, at times alternating with osteoclasts. Large and small groups of multinuclear giant cells closely resembling osteoclasts were encountered, sometimes at a distance from the trabeculae, and frequently situated in the neighborhood of hemorrhages or vascular spaces. Many whorls of fibroblasts were found in almost all of the cases. The cortical bone was very thin, forming at times a fine bony layer, interrupted at several points (Figs. 1 and 2).

In not one of the sections which had been completely resected did the writers see cartilaginous tissue which prevented extension of the monostotic dysplasia.

Rarely, after search was made in numerous fields, small groups of xanthomatous cells were seen, generally situated around blood vessels or small hemorrhages. In almost every instance, these elements were discovered only after special staining for fat. Their number was always insignificant in relation to the remainder of the tissue of dysplastic aspect.

The undifferentiated mesenchymal nature of the stroma of this process, while suggested by various authors, was not demonstrated until the fact appeared clearly when the material was studied with the special stain of Rio Hortega. This staining for reticulo-endothelial elements, a variation of which we have recommended in earlier papers [9, 12], is the only method available for studying in fixed material the distribution and morphology of reticulohistiocytic cells.

The microscopic analysis of our histological sections, studied according to the technique of Rio Hortega, showed the abundance of reticulo-endothelial elements to be widely distributed. They appeared regularly in some zones; formed syncytia in others; and showed a very minute evolution in a fibroblastic and an osteoblastic sense (Fig. 3). At times there were seen around blood vessels or small hemorrhages some elements only macrophagic in function and others being transformed into giant cells (Fig. 1, *C* and *D*). A close analysis of the zones of osteoblastic evolution shows the fundamental importance of these elements in the formation of the bone trabeculae, since it was found in the different zones examined that they were grouped like reticulohistiocytic cells, that they had lost their prolongations, and that a fundamental substance was given off which appeared between them. This substance was formed especially by enlargement and by collagenous transformation of the pre-existing and newly formed reticular fibrils, which later were impregnated with calcium granules. The techniques employed show that the homogeneous picture of the fundamental substance of the so-called osteoid trabeculae, as they are demonstrated by the usual techniques, corresponds to a compressed network of connective-tissue fibers which are continuous with those of the stroma encircling them (Figs. 3, 4-A, 4-B, 4-C, 5-A, 5-B, and 5-C).

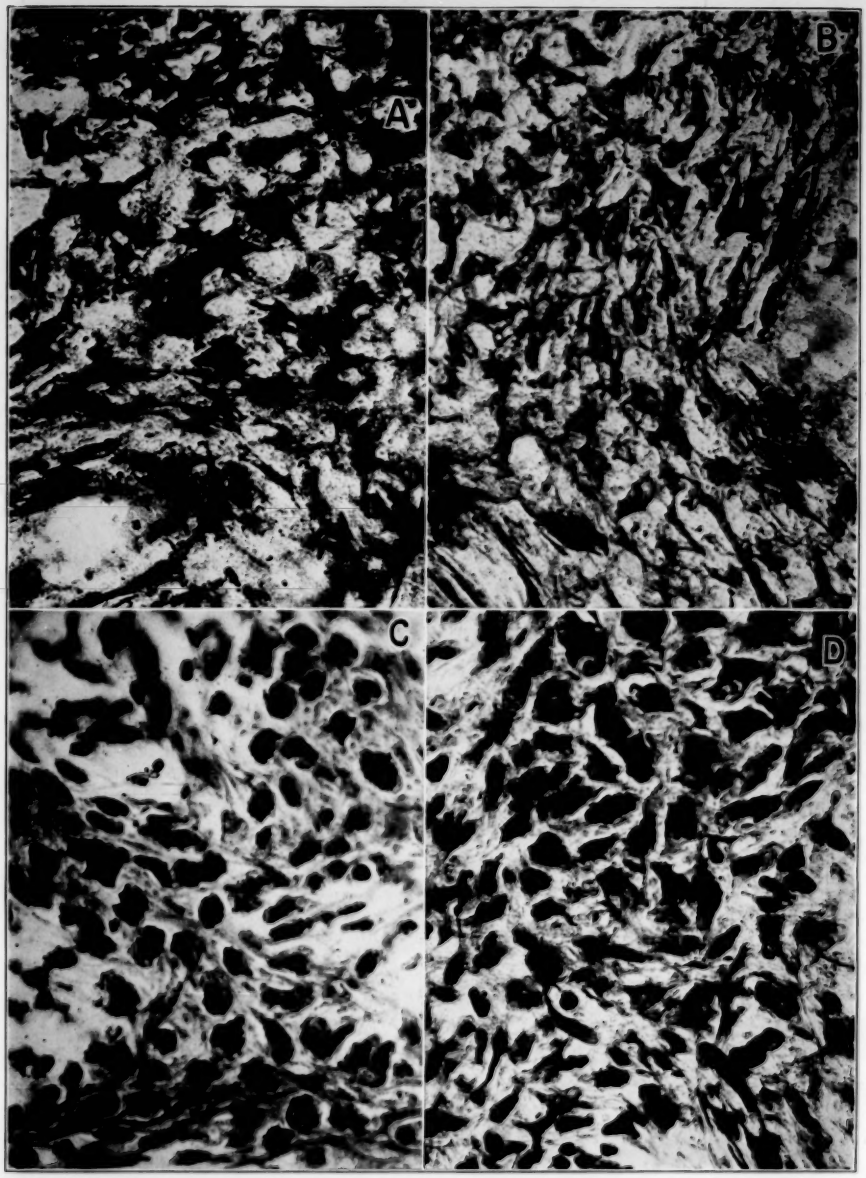

FIG. 3

The reticulohistiocytic nature of most of the elements which constitute the dysplastic tissue can be seen in *A* and *B*. Here the reticulo-endothelial cells have been impregnated with the corresponding stain of Rio Hortega.

C and *D:* The osteoblastic evolution of the cellular elements of the primitive mesenchyme is evident, showing a trabecular arrangement. In *C*, collagenous fibers are present in the trabeculae.

The techniques of Rio Hortega, Ramón and Cajal, and Bielschowsky for nerve elements did not show in this tissue the existence of nerve fibrils or of Schwannian elements. These same techniques serve, therefore, to confirm in an indirect manner the authentic mesenchymal structure of the whorls. This fact has also been demonstrated by the use of the techniques of Rio Hortega for connective tissue.

2. *Polyostotic Form*

The pathological anatomy of this form is fundamentally identical, except for the possible finding of cartilaginous masses, which one may encounter in small amounts in this process [1, 5–8]. These are formed from adult cartilage with abundant hyaline ground substance, which separates the nests formed by small groups of proliferating cartilaginous cells. This cartilage does not show signs of calcification, this being present only in a few

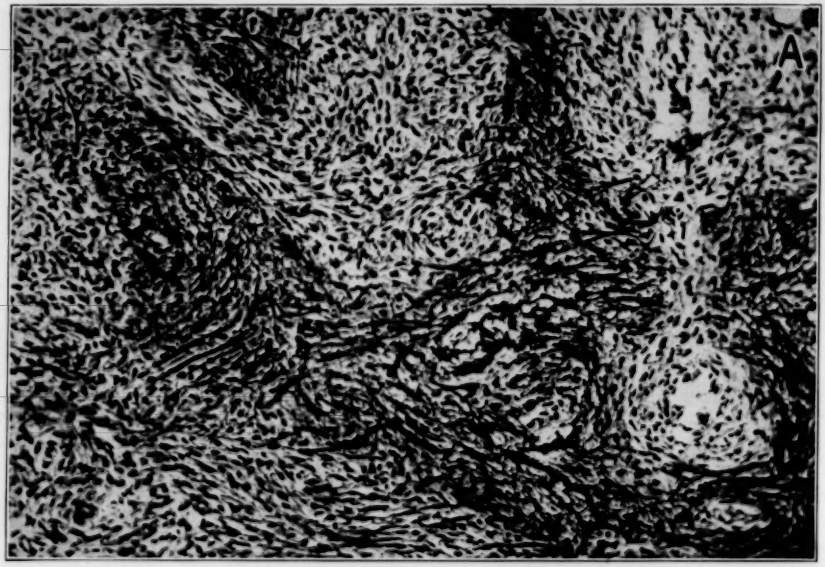

FIG. 4-A

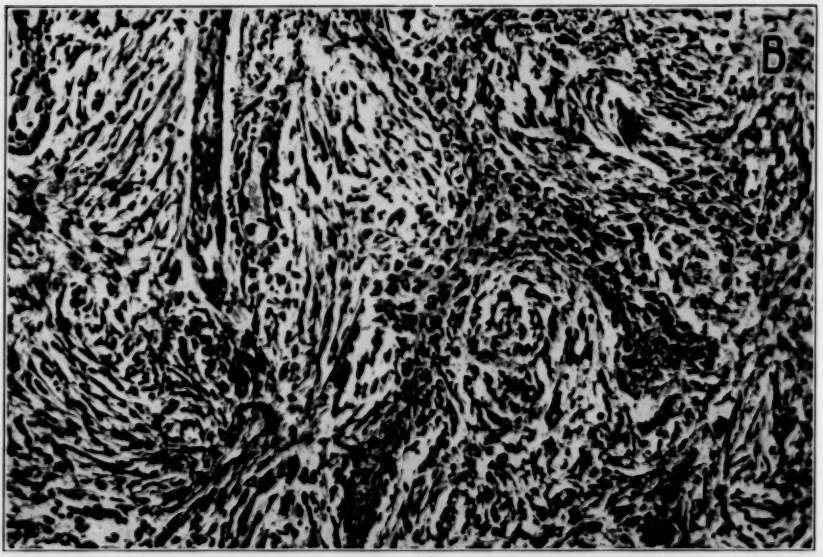

FIG. 4-B

Photomicrographs showing successive stages of the formation of bone trabeculae, originating from the reticulohistiocytic elements of the dysplastic tissue.

FIG. 4-C
The trabeculae appear to be already calcified.

points at the periphery of the lobules. Likewise the replacement of the cartilage by osseous tissue takes place only in rudimentary form. Between the cartilaginous lobules are wide zones occupied by fibrous tissue with many osteoid and reticular trabeculae. In other words, they have the same appearance as in the adjoining dysplastic zones (Fig. 7).

If the presence of the cartilaginous tissue is excluded, the writers feel that the histological aspect cannot be differentiated from that found in generalized osteitis fibrosa or hyperparathyroidism (in which cartilaginous tissue is not observed). This opinion differs from that of Jaffe, who affirmed that the histological differential diagnosis between both processes is an easy one to make. Moreover, Dockerty and his co-workers and MacMahon believed that differentiation between both processes by histological examination alone is impossible.

At times difficulties are encountered in the diagnosis of chondrodysplasia if, in the biopsy, one comes upon a cartilaginous zone which from the roentgenogram might also be interpreted as Ollier's disease. However, the histological examination of other pieces and a biopsy of another bone will aid in making a definite diagnosis of polyostotic fibrous dysplasia. Such a case, actually encountered by the writers, showed clearly the relationship between both processes, and constituted a very important argument in favor of the dysplastic origin of the process under discussion.

DISCUSSION

Our investigations do not permit us to affirm emphatically, as have Lichtenstein and Jaffe and other authors, that the term "fibrous dysplasia" can be applied with certainty to the solitary form. This is especially true when the term is applied to such a group of processes as osseous xanthomata (xanthomatous histiocytic granuloma) [12], ossifying fibroma [14], and leontiasis of bone [17], which in the writers' opinions have their own specific individuality.

Moreover, it has been observed by other investigators that several processes of inflammatory, metabolic, and traumatic origin may show, as a final reparative picture or

reaction, reticulohistiocytic proliferation with zones of fibroblastic and osteoblastic evolution. This histological picture is identical with that seen in monostotic fibrous dysplasia.

On the other hand, we believe that the term "polyostotic fibrous dysplasia" is a more

FIG. 5-A

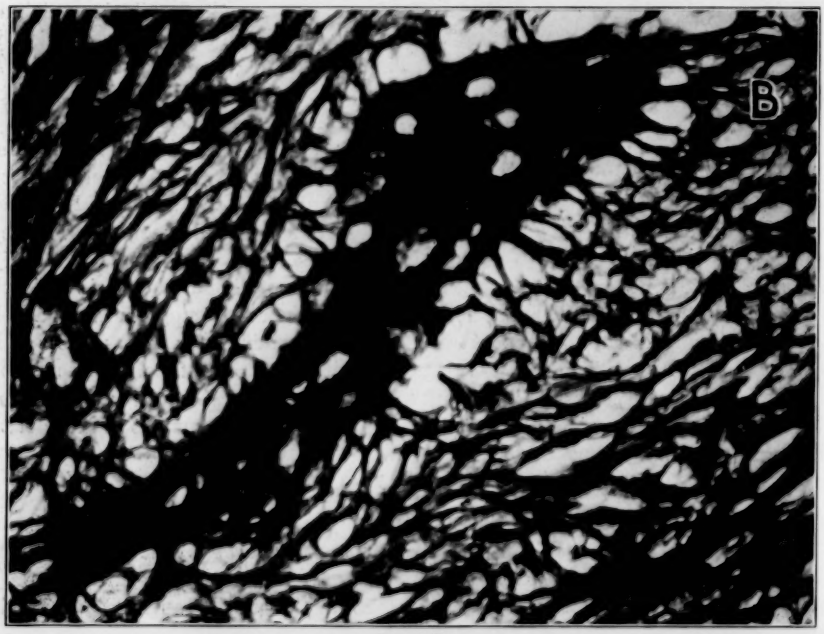

FIG. 5-B

Photomicrographs showing stages seen in Figs. 4-A and 4-B, but with the stain of Rio Hortega for collagenous reticular fibers. Note the continuity between fibrils of the stroma (dysplastic tissue) and those which cross and form the fundamental substance of the bone trabeculae.

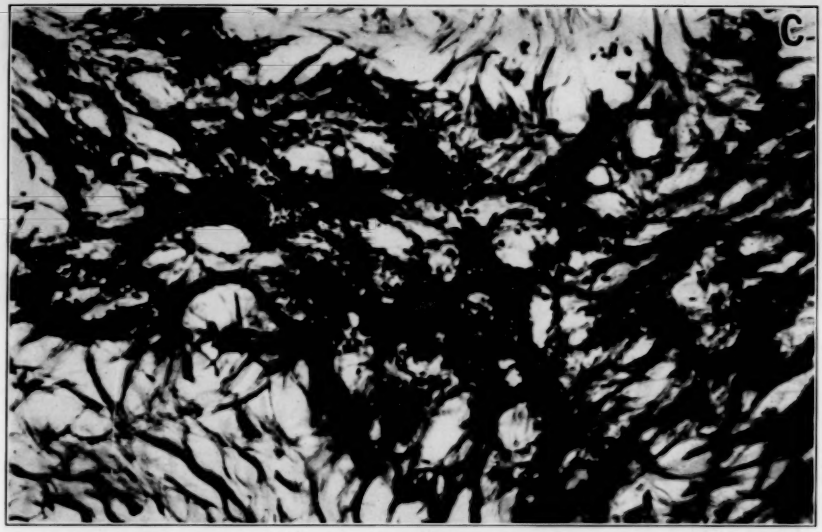

FIG. 5-C

This substance is found to be impregnated with granules of calcium.

adequate name than those previously employed, because we have proved in this group, as have others before us, the presence of large cartilaginous masses in plain mesenchymal

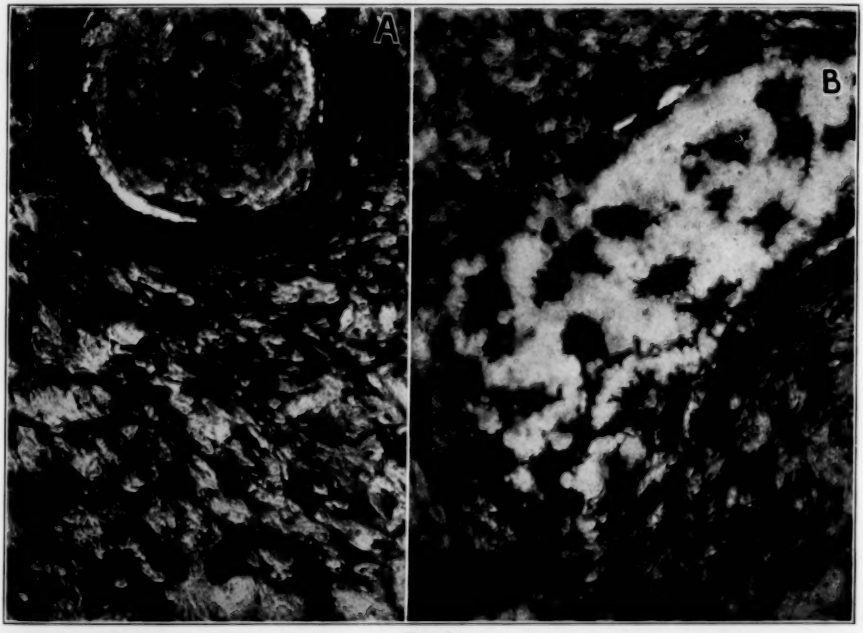

FIG. 6

Photomicrographs showing reticulohistiocytic nature of the cellular elements of the dysplastic stroma and of the osteocytes. The variant of the Rio Hortega stain for reticulo-endothelial elements has been used. *A* shows osseous trabeculae to be more mature and calcified. *B* shows young ramified osteocytes.

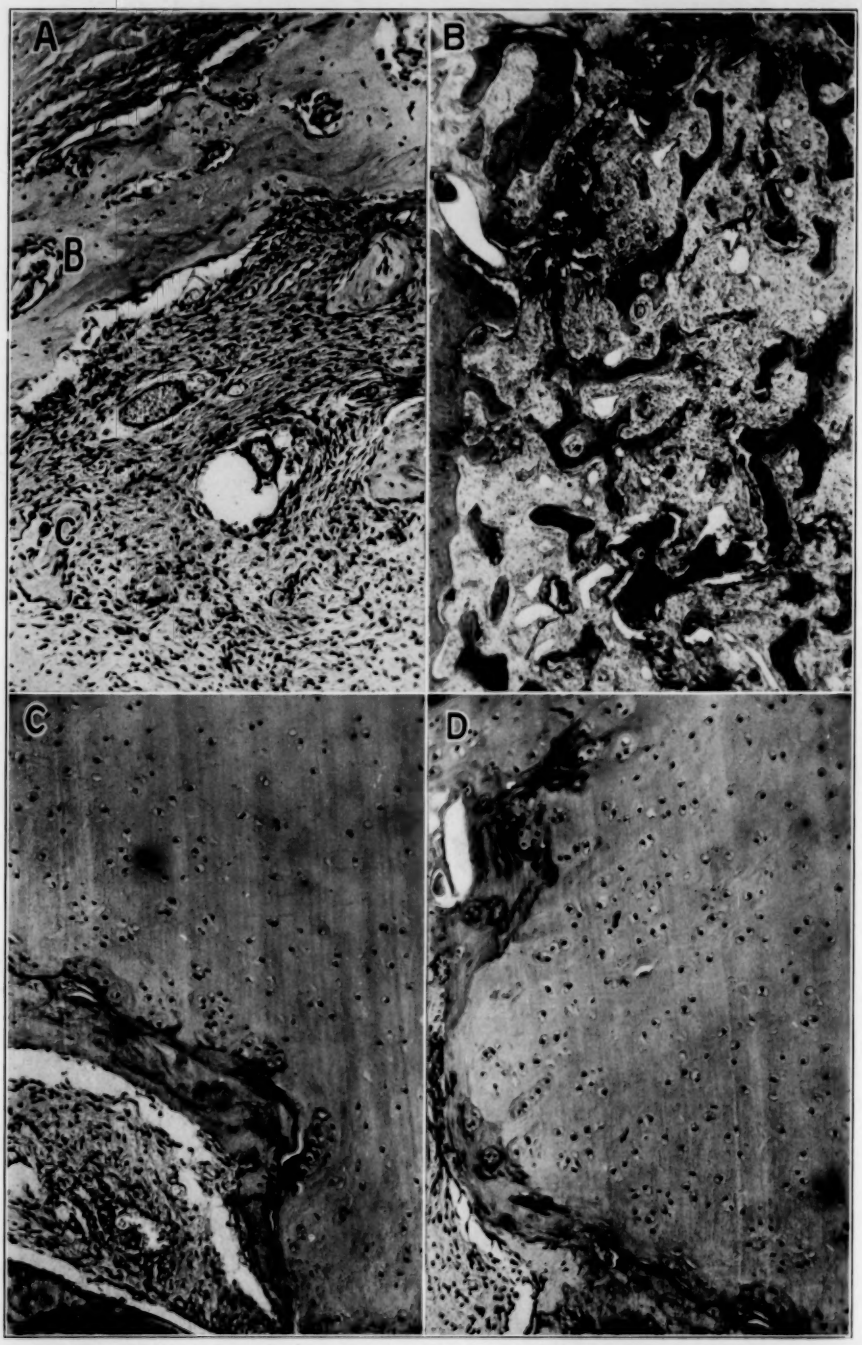

FIG. 7

General histological characteristics in a case of polyostotic fibrous dysplasia. In *C* and *D*, hyaline cartilaginous nodules are seen to be limited by a tissue typical of fibrous dysplasia, as seen under lower power in *A* and *B*.

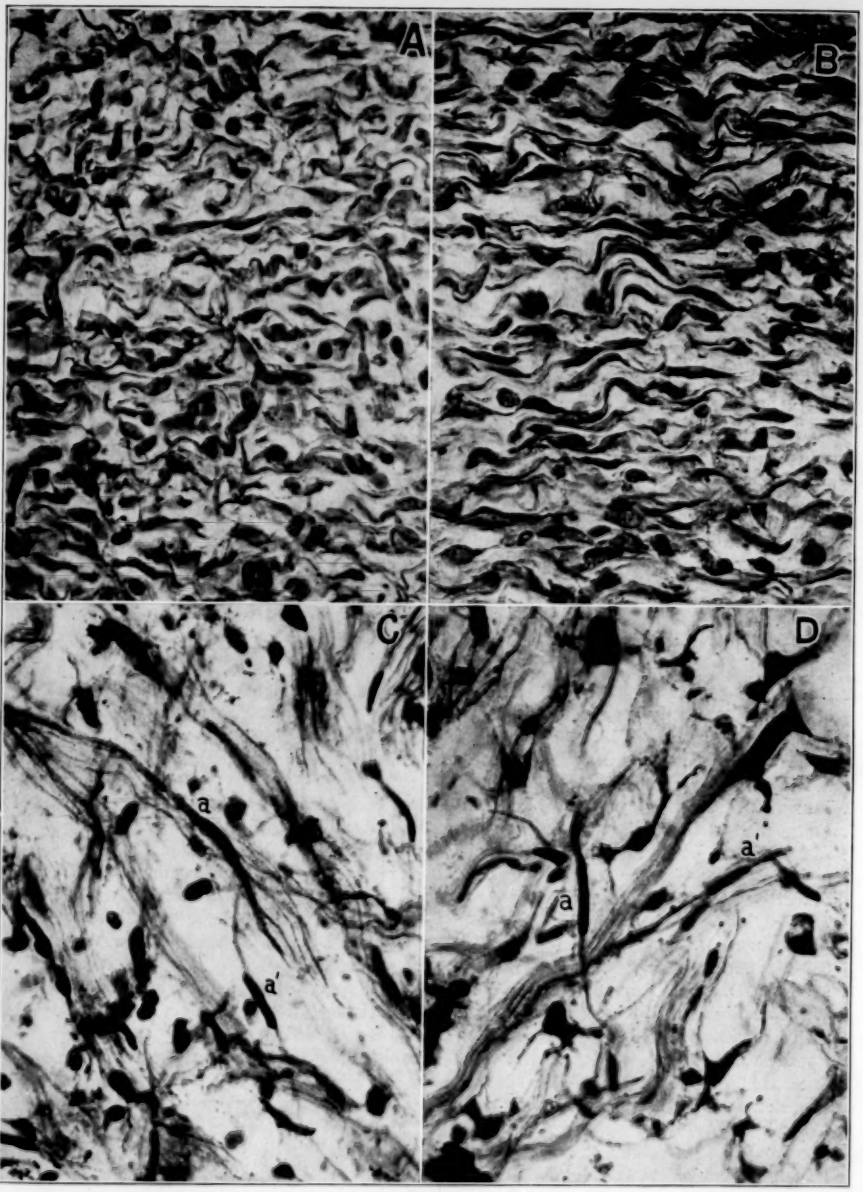

FIG. 8

Photomicrographs showing structural characteristics of a neurofibroma. In *A* and *B* fibroblasts and histiocytes are seen, among which the specific cells (lemmocytes) are placed. In *C* and *D* these cells show typical elongated aspect, with rodlike nuclei and cytoplasm extended in two prolongations (*a*—*a'*).

tissue. These factors, together with other clinical and roentgenographic features, would seem to confirm the relationship with a process in which the dysplastic congenital origin is unquestionable,—chondrodysplasia or Ollier's disease.

On the basis of our studies, performed with special silver-impregnation techniques, the writers believe that there is no relationship between fibrous dysplasia and the neurofibromatosis of von Recklinghausen, as held by Ferrero and Thannhauser. The exhaustive

investigations of Rio Hortega [11] have shown in neurofibromatosis the presence of specific cells, "*lemmocitos*", of neural origin (ectodermal) and accessory cells, fibroblasts and histiocytes. The lemmocytes are elongated, have rodlike nuclei, and scarce cytoplasm which terminates in two or three thin prolongations, designated by Rio Hortega as "*neuritides*". These cells are never anastomotic, nor do they form syncytia. If sometimes the latter do appear, they occur in the connective-tissue elements (Fig. 8). Rio Hortega's investigations and the photomicrographs illustrating this paper would seem to prove that no morphological similarity exists which would permit confusion between the specific and the accompanying connective-tissue cells.

In our own cases we have never found lemmocytes among the connective-tissue cells or in the whorl formations, and we have always considered our findings to be true mesenchymal cells. Moreover, the presence of nerve fibers would not justify the diagnosis of neurofibromatosis in any event, because such fibers, either normal or degenerated, can be observed in any tissue, whether it be tumor tissue or normal tissue.

While the writers acknowledge that the problem is a difficult one, from the foregoing it would seem that the polyostotic form may be accepted as a real dysplasia, while the monostotic form in many instances corresponds to the final cicatricial stages of processes, rather than to dysplastic stages. In those cases where a thorough search of the clinical and histopathological material fails to reveal some other etiology, we should concur with the classification of Jaffe and Lichtenstein.

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FIBROUS DYSPLASIA OF BONE

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The term "fibrous dysplasia" has been employed in recent years to designate certain types of osseous changes that may either be limited to a solitary focus (monostotic fibrous dysplasia) or distributed in multiple areas (polyostotic fibrous dysplasia). The etiology and pathogenesis of both forms have remained obscure, and opinions have differed as to the possible relationship of one disease process to the other and to the condition known as Albright's syndrome.

It is the purpose of this report to compare the clinical, roentgenographic, and pathological findings, and to note the effects of treatment in the three types of disease. During the past three years we have studied seven patients, each having a solitary osseous lesion, three patients with two or more defects, and one patient showing widespread changes, precocious puberty, and areas of dermal pigmentation.

An analysis of the data presented in Table I reveals that nine of the patients were between six and sixteen years of age. The remaining two patients were thirty-seven and thirty-eight years of age. There were six males and five females in this series.

Clinical Manifestations

The long bones of the lower extremity were most commonly involved. Pain, of varying intensity, was a symptom common to all patients. In five patients, the pain had an insidious onset and gradually increased in severity, while in the remaining cases it began suddenly following minor injuries. In five persons, trauma resulted in pathological fractures. Pigmentation of the skin was noted in only four patients, two with monostotic lesions, one with polyostotic disease, and one with Albright's syndrome. An area of pigmented skin (Fig. 1-A) was removed from one patient (Case 11). Microscopic examination of this specimen revealed as the only abnormality an excessive amount of melanin in the deeper layers of cells in the epidermis.

Laboratory Studies

Laboratory examinations included complete blood and urine studies for each patient, but no consistent abnormalities were noted. The blood calcium, inorganic phosphorus, and cholesterol values were within normal limits in each instance. Two patients (Cases 10 and 11) showed elevations in alkaline phosphatase within a few days following the occurrence of pathological fractures. In one instance (Case 10) the alkaline phosphatase went up to 20.3 Bodansky units, and in the other (Case 11) it rose to 12 Bodansky units. In both patients the values returned to normal within a few weeks.

Roentgenographic Appearance

The roentgenograms of the osseous lesions showed either a "cystic" or a "ground-glass" appearance. Lesions resembling bone cysts showed areas of radiolucency of varying sizes (Figs. 1-B, 1-C, 2-A, 2-B, 3-A, 3-B, 4-A, and 4-B). There was no zone of increased density surrounding the radiolucent area. In some of the cystic lesions the bone was expanded and the cortex was thinned. None of them had a multilocular appearance. The ground-glass appearance was characterized by areas of homogeneous or granular density, obliterating the medullary space (Figs. 5-A, 5-B, 6-A, and 6-B).

FIG. 1-A

Case 11. A ten-year-old girl with Albright's syndrome. Note the dermal pigmentation, the deformity of the left hip from two previous pathological fractures, and the signs of precocious sexual development.

FIG. 1-B

Fig. 1-B: Case 11. Roentgenogram showing a fracture at junction of upper and middle thirds of the femur, with angulation of the distal fragment. The break occurred at the lower end of a fibrocystic lesion. Also note similar cystic areas in the ilium and ischium.

FIG. 1-C

Fig. 1-C: Appearance of same femur, seven months after application of tibial bone graft and metal plate.

TABLE I
ANALYSIS OF CASES

Case No.	Age and Sex	Site of Lesion	Symptoms	Pathological Fracture	Pigmentation of Skin	Treatment	Results
				A. Monostotic Group			
1	6, F.	Tibia	Pain in leg due to a fall	Yes	None	Resection and sliding bone graft	Relief of pain; union of fracture
2	16, M.	Femur	Pain and swelling of knee after a fall	No	None	Curettement of lesion	Eradication of lesion and relief of pain
3	16, M.	Tibia	Pain in leg due to a fall	No	One *café au lait* spot	Resection; filling of cavity with tibial bone chips	Eradication of lesion and relief of pain
4	13, M.	Tibia	Insidious onset of pain, swelling, and redness of knee	No	None	Resection	Relief of pain, but tendency to residual cyst formation
5	12, F.	Humerus	Pain in arm after a fall	Three times	None	Curettement; filling of cavity with tibial chips	Union, relief of pain; small cystic area remained
6	8, F.	Neck of femur	Insidious onset of pain in groin	No	Abdomen and knees	Curettement; filling of cavity with iliac chips	Relief of pain; normal range of hip motion
7	37, F.	Ulna	Insidious onset of pain in wrist	No	None	Excision	Slight limitation of supination; no pain
				B. Polyostotic Group			
8	6, M.	Tibia and fibula	Pain and swelling in leg after a fall	Yes (Tibia)	None	Excision of tibial lesion and bone graft from right tibia	Excellent union; slight anterior bowing of tibia
9	38, M.	Fifth lumbar vertebra, both fibulae	Insidious onset of pain in low back and knee	No	None	Spine fusion; biopsy of right fibula	Partial relief of low-back pain
10	8, M.	Left femur, radius, and ulna; right fibula	Insidious onset of pain in left thigh, later aggravated by fall	Yes (Left femur)	Back, neck, shoulders, and buttocks	Closed reduction of fracture of femur; biopsy of fibula	Good union of fracture and complete relief from pain
				C. Albright's Syndrome			
11	10, F.	Both femora, left fourth and sixth ribs, left and right ilia, and left fibula	Pain in left hip due to a fall; menstruation began at 1½ years of age	Yes (Left femur, twice)	Left lumbar, lumbosacral, and right sacroiliac regions; left thigh	Open reduction and fixation of femur with metal plate and tibial bone graft; biopsy of rib	Fracture healed well in six months

FIG. 2-A

FIG. 2-B

Fig. 2-A: Case 2. Roentgenogram revealing radiolucent area in distal end of femur.
Fig. 2-B: Same area of femur, seven months following curettement of lesion.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Case 8. Roentgenogram showing expansion and rarefaction of the tibial cortex.
Fig. 3-B: Nine months following resection of lesion and replacement with bone graft from the right tibia. The lesion appears healed.

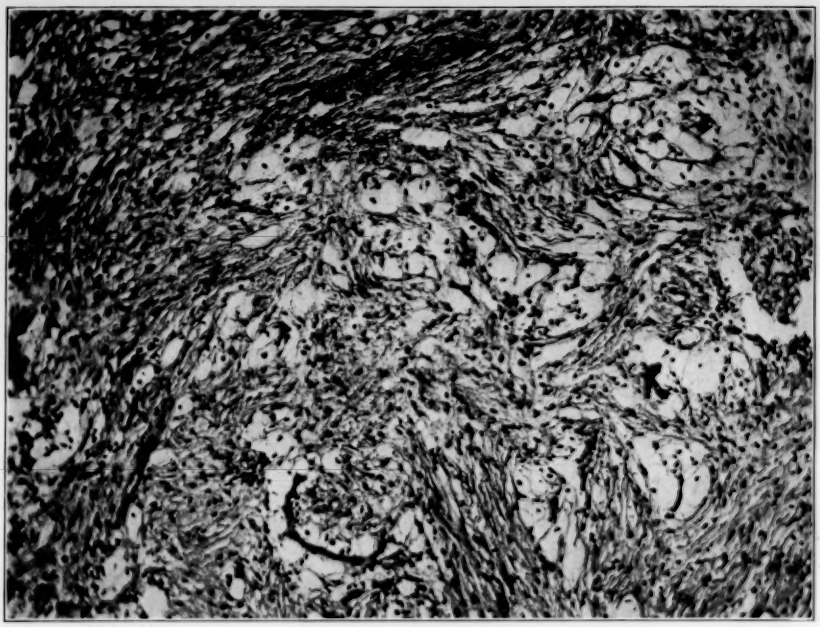

FIG. 2-C

Case 2. Photomicrograph (× 152.5) showing focal collections of foam cells surrounded by strands of fibrous connective tissue.

Pathological Changes

Tissue specimens from the osseous lesions of all patients in the series were obtained by biopsy or by resection of all or of a substantial portion of an affected area.

Gross inspection revealed variable appearances, depending upon the amount of bone that was contained in a given lesion and upon the degrees of vascularity and extravasation of blood. In those specimens where little or no bone was forming in the replacement tissue (Figs. 4-A, 8-A, and 8-B), the original cortex was reduced to a thin shell of expanded bone and the defect was filled with tough, fibrous tissue that was either firm and rubbery in consistency or somewhat soft and oedematous. In color, these specimens varied from white to pale yellow. The lesions giving rise to a ground-glass appearance in the roentgenograms (Figs. 5-A and 5-B) were remarkably similar. The bone shafts were widened and the visible cortical layers were thin and poorly demarcated. The tissue replacing the medulla was pale gray or white and, depending upon the amount of bone contained, it was either hard like cancellous bone or dense and rubbery in consistency. In specimens of the latter type, gritty particles, representing scattered, imperfectly formed trabeculae, were noted.

Microscopically, the lesions were of two main types: ossifying and non-ossifying. Both types exhibited masses of fibrous connective tissue, composed of spindle cells arranged in whorls or strands, replacing normal cortical and cancellous bone and marrow. However, in the ossifying lesions, small or large amounts of cancellous bone were laid down in the replacement connective tissue (Figs. 5-C, 5-D, 7-A, and 7-B). These lesions occurred in six cases. In the second type the new-bone formation was not noted (Figs. 8-A and 8-B). Another feature noted in three cases was the presence of foam cells (Fig. 2-C). Five of the lesions exhibited giant cells, scattered throughout the fibrous connective tissue (Fig. 9).

FIG. 4-A FIG. 4-B FIG. 5-A FIG. 5-B

Fig. 4-A: Case 5. Roentgenogram showing large cystic lesion with thinned cortex in the middle of the shaft of the left humerus.
Fig. 4-B: Roentgenogram of same humerus, fifteen months following curettement of lesion and filling of cavity with bone chips.
Fig. 5-A: Case 10. Roentgenogram of left femur which reveals coxa vara deformity, loss of trabecular pattern and varying density through the upper shaft, and a spiral fracture at the junction of the upper and middle thirds of the shaft.
Fig. 5-B: Roentgenogram showing widening and medial bowing of the central portion of the right fibula, with a "ground-glass" appearance of the middle portion. A similar change is also seen in the left fibula.

FIG. 5-C

FIG. 5-D

Fig. 5-C: Case 10. Photomicrograph (× 8.5) showing replacement of the medullary cavity of the fibula with fibrous connective tissue and irregularly arranged cancellous bone. Marked thinning of the cortex is apparent at the right side of the reproduction.

Fig. 5-D: Histological details of the lesion are shown in this photomicrograph (× 156). Active lacunar resorption of bone in focal areas is apparent.

Treatment

All of the patients received surgical treatment except one (Case 10). He had involvement of several bones, including a pathological spiral type of fracture of the left femur; the fracture was reduced by manipulation, and a hip spica cast was applied. Because of extensive involvement of the femur, a resection of the lesion was not feasible. Tissue for study was obtained from a biopsy of a lesion in the fibula having a similar roentgenographic appearance. The fracture healed in twelve weeks.

Another patient (Case 11) also had too extensive involvement of the femur for a resection of the lesion. Since she had sustained her second fracture in the same area within four years, it was decided to perform an open reduction and fixation with a tibial bone graft and a metal plate. Good union resulted (Fig. 1-C).

One man (Case 9) had lesions in both fibulae and the anterior superior aspect of the fifth lumbar vertebra, but his chief presenting complaint was low-back pain of several years' duration. A diagnosis of fibrous dysplasia was made from a biopsy of a fibula. Spine fusion resulted in partial relief of his low-back pain.

The lesions were removed in all of the other patients, either by resection or by curettage. In three instances, the cavities were filled with bone chips, and in two the resected areas were replaced by onlay tibial bone grafts. In three patients bone chips or grafts were not used, since the cavities were small.

Pain was relieved in all of these patients, and has not recurred within two to three years postoperatively. Follow-up roentgenographic examinations revealed a tendency to residual cystic formation in Cases 4 and 5, but no abnormal appearance was evident in the other cases.

FIG. 6-B

FIG. 6-A

Fig. 6-A: Case 6. Roentgenogram showing an area of rarefaction on the medial and inferior aspect of the left femoral neck.
Fig. 6-B: Same femur, eight months following curettement and filling of cavity with iliac-bone chips.

FIG. 7-A

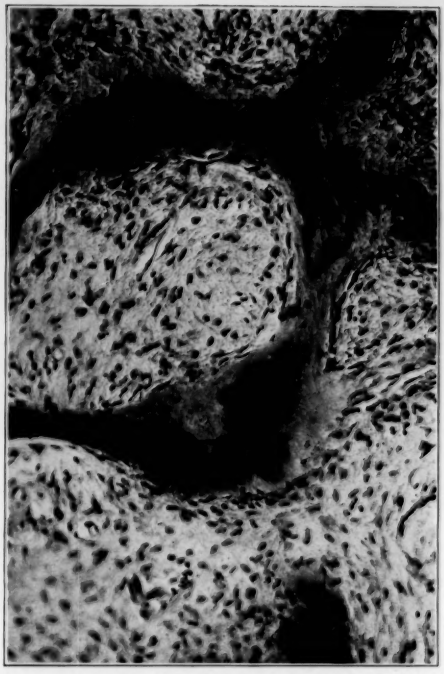

FIG. 7-B

Fig. 7-A: Case 9. This photomicrograph (× 9) shows a thin layer of cortical bone which surrounds a medulla composed of irregularly arranged and narrow trabeculae. The marrow spaces are filled with a moderately cellular fibrous tissue.

Fig. 7-B: High-power reproduction of the same section (× 165). The trabeculae are surrounded by osteoblasts, beneath which are seams of poorly calcified new-bone matrix.

DISCUSSION

Monostotic and polyostotic lesions in bone, giving rise to cystic and ground-glass changes in the roentgenograms; pain, deformity, and pathological fractures upon clinical examination; as well as a wide variety of gross and microscopic changes on tissue examination have been the bases of many reports in the literature. Numerous terms, including "osteitis fibrosa cystica localisata" [6, 22], "osteodystrophy fibrosa" [13, 23, 29], "fibrocystic disease" [1], "osteitis fibrosa disseminata" [7], "localized fibrous lesions" [17], "non-osteogenic fibroma" [19], "ossifying fibroma" [16], and "fibrous osteoma" [24], have been used at times to designate similar or identical lesions, the basic morphology of which includes replacement of cortical and cancellous bone and marrow by fibrous connective tissue containing varying amounts of imperfect cancellous bone.

The term "fibrous dysplasia" was introduced in 1938 by Louis Lichtenstein in describing fibrous lesions involving more than one bone. Since then many other writers [8, 10, 14, 15, 18, 21, 25, 28, 32] have used the same term.

Pathogenesis

Our observations, like those in earlier studies, have failed to elucidate the etiology or pathogenesis of fibrous dysplasia of bone. Therefore, we shall mention only a few of the theories which have been advanced.

In 1922, Weil presented a case of a nine-year-old girl with abnormal pigmentation of the skin and precocious puberty, who had suffered seven spontaneous fractures. He

suggested that the sexual development may have been due to abnormality of the suprarenal glands, but was unable to explain the spontaneous fractures except to say that the roentgenographic appearance of the bones suggested that the patient had an unusual variety of osteopsathyrosis.

In 1937, McCune and Bruch observed a similar case, and suggested that the lesions may have resulted from one of three causes: (1) an atypical variety of von Recklinghausen's neurofibromatosis, (2) an unusual type of xanthomatosis, or (3) an unidentified disease of the hypothalamic region of the brain. Albright and his associates [2, 3] considered that the syndrome may be an expression of an underlying neurological disturbance or of an embryological defect. The precocious puberty in females, they thought, may be due to a disturbance in the follicle-stimulating hormone in the anterior pituitary. Braid proposed that a function of the liver concerned with the storage and utilization of vitamins had been damaged, resulting in disturbance of bone growth, since in some cases there is coexistent icterus gravis neonatorum.

FIG. 8-A

Case 7. Reproduction (× 10) showing the fibrocellular character of the tissue replacing a segment of ulna. Large and small areas of bone replacement were in evidence on roentgenographic examination and at operation.

FIG. 8-B

The dense fibrous character of the replacement tissue is illustrated in this photomicrograph (× 180). Note the absence of cancellous bone.

Freund, in 1934, commenting on a case of osteodystrophia fibrosa unilateralis, believed that the fibrous changes were due to active hyperaemia of the bone tissue, ascribed to anomalies in the sympathetic nervous system; these changes resulted in paresis of the muscular coat of the blood vessels and vascular dilatation. In a study of forty-five patients with fifty-one fibrous lesions in the lower extremities, Hatcher noted concomitant epiphyseal disorders in fourteen, and, therefore, thought they might have had common pathogenesis, due to vascular derangement. He also raised the question of relationship to trauma, since the onset of pain in many cases followed an injury. Bremer theorized that the lesion may result from "long-continued excess of estrogen, probably acting through the parathyroid glands".

In 1938, Lichtenstein proposed that fibrous dysplasias were the result of abnormal development of the undifferentiated fibrous tissue which normally gives rise to the substantia spongiosa and to the myeloid substances or

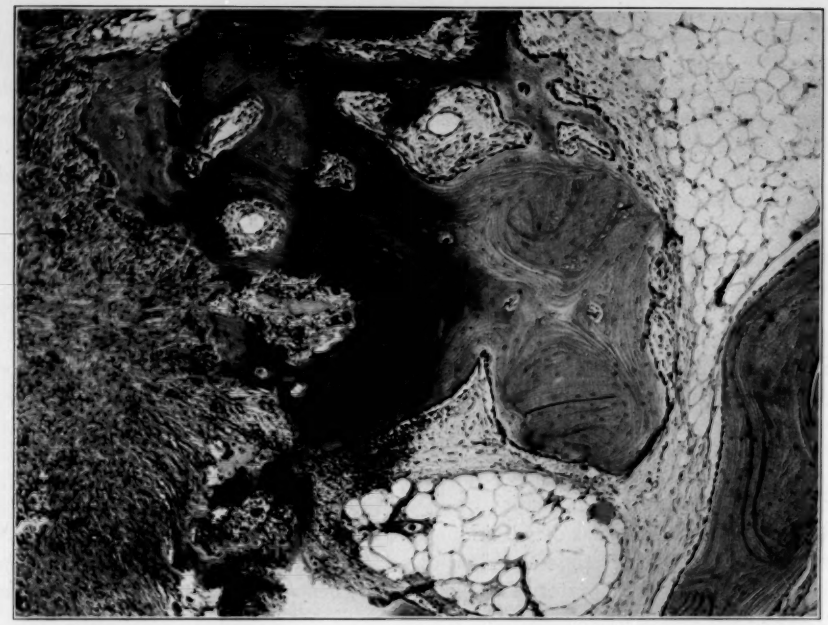

FIG. 9

Case 4. In this reproduction (× 67.5), active bone resorption at the margin of the cystic lesion is evident. There is also some fibrosis of the marrow spaces surrounding the destructive process. Many multinucleated giant cells can be seen.

fatty marrow. In 1942, he and Jaffe [21] stated that the condition may affect one, several, or many bones. They believed that extraskeletal manifestations, such as pigmentation of the skin, premature sex development in females, hyperthyroidism, and premature skeletal growth and maturation manifest themselves principally in cases in which the skeletal lesions are relatively severe and extensive, and only occasionally in those less severe.

Thannhauser, in 1944, attempted to classify fibrous dysplasia of bone with von Recklinghausen's neurofibromatosis. However, we are in agreement with Jaffe, who stated that fibrous dysplasia is "a disease entity and specifically not an expression of neurofibromatosis". Pigmentation of the skin, when associated with fibrous dysplasia, is not attended by collections of naevus cells or recognizable neural elements.

Because of the fact that foam cells are often found in lesions of fibrous dysplasia, Snapper stated that the condition is really a lipoid granulomatosis of bone "without craniohypophyseal localization". He argued that all those lesions which have been described and which did not contain foam cells were old lesions. However, he did not present definite evidence to prove the relationship. In view of the normal blood-cholesterol findings in our cases, and because of the fact that foam cells, when present, have such a spotty distribution, we feel that they are probably lipoid-laden phagocytes.

There is little evidence to suggest that either trauma or infection can be regarded as a causative factor in any form of fibrous dysplasia. Neither is there any evidence to suggest that the disease is hereditary in nature. Although Coley and Stewart observed bone sarcoma in two cases of polyostotic fibrous dysplasia in 1945, the condition is not generally regarded as having malignant tendencies.

There has been much discussion as to whether or not the monostotic [25] and polyostotic [20, 21] forms of fibrous dysplasia and Albright's syndrome [3, 4, 9, 11, 27] can be regarded

as the same disease process. The answer to this question must await more precise information concerning the histogenesis of the bone lesions, and a better understanding of the biological phenomena that account for the dermal lesions, the disturbances in skeletal growth, and the frequently associated disorders of endocrine physiology. It is clearly evident, however, that the skeletal changes noted in patients with monostotic lesions are indistinguishable from those observed in subjects with polyostotic lesions, including those who present all of the manifestations of Albright's syndrome. Thus far, no consistent anatomical abnormalities have been observed in any of the endocrine glands of affected patients. This fact and the focal distribution of the bone defects suggest that a specific form of endocrine dysfunction is not the sole cause of the disease.

It has been emphasized repeatedly that, irrespective of the extent to which the various manifestations of the disease have developed, the skeletal changes represent the nucleus or common factor of fibrous dysplasia. The skeletal changes are similar in all cases, except that in some lesions cancellous bone is laid down in the replacement connective tissue (ossifying fibroma), while in others it is absent (non-ossifying fibroma).

Diagnosis

The diagnosis of fibrous dysplasia may sometimes be made from the history and the physical and roentgenographic examinations, but often it is made only after the lesion has been exposed. The laboratory findings are of no benefit, except that by their normalcy they aid in the differential diagnosis.

The usual case history is that of a child, usually five to fifteen years of age, whose first symptom is an insidious onset of dull, aching type of pain, with or without local swelling and tenderness in the region of the involved extremity or extremities. Often the onset may follow trauma, although it has not been shown that trauma is a factor in producing the lesion. Sometimes the first indication of any pathological changes in the skeleton is severe pain and disability following minor trauma, at which time the roentgenograms reveal evidence of a pathological fracture. Although the diagnosis is made in most cases before adolescence, in many the symptoms did not occur until adult life. In Case 9 (aged thirty-eight) slight bowing of the legs led to roentgenographic examination and later to biopsy, in order to confirm the diagnosis of fibrous dysplasia of the fibula. The patient's only complaints had been referable to the lesion in the spine. In Case 7, pain in the forearm first developed at the age of thirty-five years. Schlumberger recently reported sixty-nine cases, in sixty-seven of which only one bone was involved. These specimens were studied at the Army Institute of Pathology. The ages of the patients varied from eighteen to thirty-eight years, and most of them had not had symptoms in childhood. Therefore, it is reasonable to assume that mild lesions of fibrous dysplasia may be undetected throughout life, if they do not progress to such an extent as to produce pain or pathological fracture.

As mentioned previously, lesions involving more than one bone may be associated with pigmentation of the skin and precocious puberty in females (Albright's syndrome). Pigmented areas and bone lesions are usually predominantly unilateral. Case 11 is a typical example. Several patients, including the first case reported in this country [23], also have had hyperthyroidism, although there was no evidence of it in our case. In 1942, Falconer and Cope reported two cases of Albright's syndrome, in both of which the patients suffered from severe failure of vision and showed acromegalic features.

There has been some speculation as to whether or not the equivalent of Albright's syndrome ever occurs in males. While there has not to our knowledge been any case of proved sexual precocity in males with this syndrome, precocious bone age and all the other findings have been reported in some cases. Albright and his associates reported one such case in 1937. Our Case 10 exhibited the classical polyostotic lesions and pigmenta-

tion, but there was no evidence of sexual precocity, and the roentgenograms showed normal bone maturation for the age of the patient.

While nearly all cases of polyostotic fibrous dysplasia exhibit areas of pigmentation of the skin, such areas are not so often found in monostotic cases. None of the sixty-seven cases with monostotic dysplasia reported by Schlumberger had such areas. Only two of our monostotic cases (Cases 3 and 6) had true *café au lait* spots.

There may be discrepancies in limb length. When a large part of the shaft of a bone is involved, as in Case 6, overgrowth may be produced. On the other hand, there may be shortening due to a pathological fracture or to premature closure of the epiphysis.

Differential Diagnosis

Hyperparathyroidism: Polyostotic lesions may simulate the roentgenographic picture of hyperparathyroidism, but the normal calcium and phosphorus levels of the former distinguish it from the high calcium and low phosphorus of the latter. Also, the lesions of fibrous dysplasia are not so generalized as those of hyperparathyroidism.

Simple Bone Cyst: Because of the similarity of roentgenographic appearance and clinical picture of a bone cyst and monostotic fibrous dysplasia, the two are often not differentiated until the lesion has been exposed. Then if a cyst is present, one finds a cavity filled with serous fluid or degenerated material, instead of with fibrous connective tissue. However, it has been argued that a bone cyst may be simply a variant of the usual lesion of fibrous dysplasia.

Giant-Cell Tumor: On roentgenographic examination, fibrous dysplasia is similar to a giant-cell tumor in that it is a cystic expanding lesion, sometimes trabeculated. Histologically, fibrous dysplasia usually shows a few or many giant cells, so that some writers have suggested it may be related to a giant-cell tumor. However, giant-cell tumors are found in the epiphyseal ends of long bones in young adults; whereas the lesions of fibrous dysplasia are usually found in the diaphysis or metaphysis, but rarely in the epiphyseal ends. The patient is usually in the age group of from five to fifteen years when the lesion is first detected. Grossly, the giant-cell tumor has a characteristic hemorrhagic, friable appearance with some areas of partially organized soft fibrous tissue. Microscopically, the basic cell is a giant cell and not a stromal cell; the latter is either a small round or fusiform immature connective-tissue cell. In fibrous dysplasia the opposite is true,—namely, the basic cell is a spindle-shaped mature connective-tissue cell; giant cells, when present, are very irregularly distributed.

Osteogenesis Imperfecta: The type of osteogenesis imperfecta encountered in infants and characterized by multiple fractures, blue sclera, and deafness does not offer a problem of differentiation. However, the type which does not become manifest until childhood, adolescence, or adult life, with the occurrence of pain or pathological fracture, may simulate fibrous dysplasia. (One patient, Case 10, had blue sclera and was thought to have osteogenesis imperfecta before entering this Hospital.) The roentgenographic examination reveals generalized osteoporosis, usually with some degree of bowing in osteogenesis imperfecta, as contrasted with the spotty distribution of either cystic-appearing lesions or the ground-glass appearance of fibrous dysplasia.

Treatment

The only known effective treatment of fibrous dysplasia is surgery, and it may be indicated when one of three conditions exists: (1) continued pain in the region of a localized bone lesion, (2) fracture through a lesion, or (3) severe bowing as a result of spontaneous fracture.

When the first condition exists, it has been found that excision of the area involved and filling with bone chips relieves the pain, although at times there is partial filling in by fibrous tissue following surgery. If the bone is extensively involved and expanded,

surgical eradication is impossible. If lesions are found to be present upon roentgenographic examination and yet produce no symptoms, there is no indication for surgical intervention. The activity in most of them seems to become stationary after adolescence, and they do not often produce pain or spontaneous fractures. Indeed, some of them even regress.

One patient, Case 8, had a lesion in the tibia, producing pain; the lesion was excised. He had a similar one in the fibula which was asymptomatic, and it was not touched. The follow-up roentgenograms showed that the lesion in the fibula had almost entirely disappeared in a few months. Whether this was a result of eradicating the lesion in the tibia, or whether it would have run the same course without surgery, is a matter of conjecture. At least it proves that surgical excision was unnecessary.

It has been shown that spontaneous fractures will heal by closed reduction, but that often pain persists. It is recommended, therefore, that when fractures occur through a cystic lesion, open reduction be performed, with excision of the lesion and application of a bone graft across the fracture site.

When severe bowing has occurred as a result of a spontaneous fracture, an osteotomy for correction of the malunion may be indicated.

SUMMARY

1. Fibrous dysplasia of bone includes monostotic lesions, polyostotic lesions, and Albright's syndrome.

2. The basic morphology of all three groups includes replacement of cortical and cancellous bone and marrow by fibrous connective tissue, containing varying amounts of imperfect cancellous bone.

3. The etiology and pathogenesis of fibrous dysplasia of bone are still obscure.

4. The diagnosis may sometimes be made on the basis of clinical and roentgenographic examinations, but often a biopsy is necessary to differentiate from other conditions.

5. Treatment consists in reduction and immobilization of pathological fractures, correction of deformities, and surgical excision of painful lesions, whenever possible.

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RESTRICTION OF BONE GROWTH BY PINS THROUGH THE EPIPHYSEAL CARTILAGINOUS PLATE *

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In a paper presented five years ago [2], it was demonstrated that the growth of bone could be mechanically retarded by a wire loop placed around the epiphyseal cartilaginous plate. It was shown that after release of the restraining wire loop, growth in length of the bone was resumed, as the growth-producing properties of the columns of cartilage cells were not permanently inhibited. It was proved that a wire loop placed about one end of the plate prevented growth on one side of the bone, and it was suggested that this principle could be applied in the correction of genu valgum or genu varum. In discussing the paper, Gerald Gill questioned whether the rate of growth was normal after the temporary retardation, or whether there was premature closure of the plate. It was thought that a band with removable pieces would be more satisfactory than a wire loop. More recently, Blount and Clarke suggested that staples could be used instead of a wire loop.

In a second series of experiments, an endeavor was made to answer some of the questions about the relative growth and to determine whether or not staples were as effective as the wire loop. It was found that growth retardation by staples was similar to that produced by the wire loop. An important observation was that staples placed on one side of bone not only prevented growth on the side of insertion, but retarded growth to a lesser extent on the opposite side, thereby causing a shortening of the bone in its entirety as compared to that of the opposite extremity. Whether this finding will have important clinical application will have to be decided by careful studies over a long growth period.

Experimentally, growth was not so active after removal of the staples or wire loop as on the opposite normal side. The removal of staples or a wire loop is attended by the possibility of permanent damage to the epiphyseal-cartilage cells, as the restraining devices become partially buried in the tissue and often are difficult to remove. Furthermore, with each additional operation, there is further damage to the blood vessels supplying the epiphyseal plate, which enter mainly about its circumference. There is also the possibility of osseous bridging, with permanent restriction of growth. If this should result in unilateral restriction, a secondary permanent deformity might occur in the opposite direction.

The main advantage of the mechanical restriction over the pioneer method of Phemister is that one can interrupt growth restriction at any desired time and allow growth to proceed in a normal manner. This could obviate the necessity of relying on predetermined calculations of growth expectancy, which are not accurate, and would also allow institution of growth restriction at an earlier age.

In seeking some method whereby one could more easily insert and remove the restraining device with a minimal amount of injury to the epiphyseal-cartilage cells, it was thought that small pins or nails would be preferable to the wire loop or staple. Accordingly, a series of thirty experiments were performed, mostly on growing rabbits, in which pins or nails were passed through the epiphyseal cartilaginous plate. A more recent series of experiments were performed on dogs, in most of which sufficient time has not elapsed to give the final results.

For the sake of brevity, the details of all the operations will not be given, but only a short report of some representative experiments.

* Read at the Annual Meeting of The American Orthopaedic Association, Colorado Springs, Colorado, May 21, 1949.

FIG. 1-A

FIG. 1-B

Fig. 1-A: Experiment 3, Rabbit 3. Pins were inserted diagonally across epiphyseal cartilaginous plate.

Fig. 1-B: Experiment 3. Showing retardation of growth at the end of 155 days. The position of the pins has changed. Lower end of bone has enlarged.

The experiments are grouped under the following headings:

1. Pins or nails were passed diagonally across the epiphyseal cartilaginous plate.
   A. Check experiments were done in which the pins were removed at once.
   B. The pins were removed after the lapse of a number of days.
2. Two crossed pins were inserted above the plate.
3. Two crossed pins were inserted on one end of the plate.
4. One or two pins were passed longitudinally through the epiphyseal plate.

1. TWO PINS PASSED DIAGONALLY ACROSS THE EPIPHYSEAL CARTILAGINOUS PLATE

Experiment 3, Rabbit 3. April 18, 1947. Duration of experiment, 155 days.

Operation: An incision was made over the lower end of the radius. The epiphyseal plate was exposed with a minimal amount of dissection, and two pins were passed diagonally across the plate (Fig. 1-A). One pin was started above the plate and one below, in an endeavor to have them cross near the center. The wound was closed with silk. No restraining dressing was applied.

Result:

Total normal growth	1.9 centimeters
Total growth of bone operated upon	0.4 centimeter
Loss of growth	1.5 centimeters

There was no growth from the lower plate. The lower end of the bone was enlarged (Fig. 1-B).

Conclusions

In none of the six experiments was there any growth from the epiphyseal plate across which pins or nails had been passed diagonally.

A. In a check experiment in which the pins were removed at once, no restriction of growth took place.

B. Two pins, inserted diagonally across the epiphyseal cartilaginous plate, were removed at the end of twenty-one days.

Experiment 22, Dog 22. July 28, 1948. Duration of experiment, 300 days.

Operation: An incision was made on the lateral aspect of the lower end of the femur. One nail was inserted above the plate and directed diagonally downward; a second nail was inserted below the plate and directed diagonally upward, crossing the first nail.

At the end of twenty-one days, the two nails were removed and a metal marker was inserted in the diaphysis. The loss of growth at this time was 0.5 centimeter.

Result at end of 300 days:

Initial length of bone	10.0 centimerers
Length of normal bone at end of experiment	15.8 centimeters
Length of bone operated upon at end of experiment	14.8 centimeters
Normal growth	5.8 centimeters
Growth of bone operated upon	4.8 centimeters
Loss	1.0 centimeter

This was the only experiment in which growth was fairly well sustained after removal of the pins or nail. In three other experiments, the growth was very much impaired.

2. TWO CROSSED PINS INSERTED ABOVE THE PLATE

Experiment 4, Rabbit 4. April 21, 1947. Duration of experiment, 162 days.

Operation: The lower end of the radius and the epiphyseal-cartilage plate were exposed. Two pins were

FIG. 2-A

FIG. 2-B

Fig. 2-A: Pins inserted above (proximal to) the epiphyseal-cartilage plate.
Fig. 2-B: Showing the pins in the diaphysis. There has been a definite restriction of growth.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Nails passed laterally through the epiphyseal plate.
Fig. 3-B: Shows restriction in growth on side of insertion, causing obliquity of articular surface. There is also a restriction of growth of the entire bone.

inserted in diagonal fashion just above the plate, crossing within the metaphysis (Fig. 2-A).

Result: At the conclusion of the experiment, the pins occupied a higher position in the diaphysis (Fig. 2-B).

Normal growth	1.9 centimeters
Growth of bone operated upon	0.9 centimeter

In two other experiments there was restriction of growth, but to a lesser degree. In the experiment reported, one of the pins passed close to the plate and may have caused some direct injury. It is difficult to explain the restriction of growth, unless the pins penetrating the periosteum cause the periosteum to exert a restraining pull on the advancing epiphysis. There is also the possibility of some injury to the epiphyseal cartilage if the pins are near the plate. Pins placed in the diaphysis caused no growth loss.

3. TWO NAILS PASSED DIAGONALLY ON ONE SIDE OF THE EPIPHYSEAL PLATE

Experiment 21, Dog 21. Duration of experiment, 75 days.

Operation: The epiphyseal-cartilage plate of the distal end of the radius was exposed through a dorsal incision, and two nails were passed through one side of the plate. One was inserted from above and passed downward and to the lateral aspect, while the other started from below and passed upward and to the lateral aspect of the bone (Fig. 3-A).

Result at end of experiment:

Length of normal bone	11.6 centimeters
Length of bone operated upon	10.7 centimeters
Loss	0.9 centimeter

The articular surface was angulated, due to the greater growth on the non-restricted side (Fig. 3-B), In one other experiment, there was a loss of total growth. Although no markers had been placed in the bone. measurement from a fixed point on the nails showed that the greater part of the growth took place from the proximal epiphyseal plate. There were signs of premature ossification of the plate, as compared to the normal.

FIG. 4-A

FIG. 4-B

Fig. 4-A: Experiment 10, Rabbit 10. Pin placed longitudinally through epiphyseal-cartilage plate.

Fig. 4-B: Experiment 10. There is a definite restriction of growth. It will be noticed that this pin passed into the articular cartilage.

4. PINS PASSED LONGITUDINALLY THROUGH THE EPIPHYSEAL CARTILAGINOUS PLATE

Rabbit 10. Duration of experiment, 166 days.

Operation: The epiphyseal plate was exposed through an incision on the dorsal surface of the lower end of the radius. After the plate had been located, a small pin was passed from above it, in a longitudinal direction, through the plate into the epiphysis (Fig. 4-A).

Result:

Growth of normal bone	1.7 centimeters
Growth of bone operated upon	0.8 centimeter
Loss of growth	0.9 centimeter

The loss of growth at the bone was 0.9 centimeter (Fig. 4-B).

In two other experiments, two pins were passed through the plate, causing a definite retardation in growth. In one experiment the pin extended into the joint.

COMMENT

The retardation of growth, when a pin or nail is inserted in a longitudinal direction through the plate, must depend upon the resistance offered by the pin in the epiphysis, preventing its normal excursion forward. In the experiment in which the nail passes into the joint, there is an additional point of resistance in the tough articular cartilage and underlying osseous tissue.

SUMMARY

Pins or nails passed diagonally across the epiphyseal cartilaginous plate prevent growth in length from that end of the bone. Such pins fix the epiphysis to the diaphysis

and prevent the progression necessary for length growth. In check experiments in which the pins were removed immediately after insertion, no loss of growth resulted. This finding rules out the possibility that the loss of growth is due to primary injury to cartilage cells.

This method has not been applied to growing humans, but its relative simplicity may warrant its use in clinical cases of discrepancy in length of the lower extremities.

The question regarding the activity of cartilage cells after removal of the restricting device—wire loops, staples, crossed pins, or nails—has not been answered completely. In most of the experiments, there is evidence that the growth property of the plate is not so active as normal, and in some instances there is almost complete loss. In removing any of the devices, there is additional destruction of the circulation to the plate, damage to the plate itself, and the possibility of producing a bridge of bone across the plate. It is believed that a method which produces less injury at the time of removal will improve the results.

It is advisable to place markers in both the normal bone and that which has been operated upon, so as to have a record of the growth from each epiphyseal plate. In some experiments, there was evidence of compensatory growth from the non-restricted plate at the opposite end of the bone. In the human, markers should be placed on both the normal bone and that which has been operated upon, for accurate study of the relative amount of growth. Also, it is recommended that careful teleoroentgenograms or scanograms be taken to obtain exact growth indices and to rule out the possibility of inaccurate measurements.

Unilateral retardation of growth was produced when two pins were inserted so as to fix only half of the plate. Some restriction was noticed on the opposite side as well, causing shortening of the entire bone. There is also the possibility of permanently damaging that side of the plate, when removing the restraining device. If permanent injury has been produced, a deformity in the opposite direction may take place.

Pins or nails passed immediately above the epiphyseal plate caused some loss of length growth. The mechanism of this restriction may depend upon fixing of the periosteum, which secondarily may hinder, to some extent, the advancement of the epiphysis away from the metaphysis.

The experiments in which the pins or nails were passed longitudinally through the epiphyseal plate produced a rather surprising amount of growth restriction in some cases. The growth retardation was most marked when the pins approached the articular cartilage.

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DISCUSSION

Dr. Walter P. Blount, Milwaukee, Wisconsin: I should like to express my gratitude for today's presentation, as well as for the similar study in 1944, when Dr. Haas used wire loops, and for his recent work with staples.

As far as children are concerned, staples have proved very satisfactory. Dr. Haas has raised several controversial points about the staples. One is the extreme effect in stopping longitudinal growth when staples are inserted on only one side of a puppy's bone. The staples that Dr. Haas used were so long that they extended almost across the bone. Growth on the other side was slowed greatly, with the effect of almost stopping longitudinal growth. Actually in children, if the staples are of the appropriate length, one can correct angular deformity without retarding longitudinal growth more than two thirds of the anticipated amount for that particular epiphysis. As Dr. Gill and Dr. Haas have both noted, there is usually a compensatory overgrowth at the other end, so that the total shortening is not great. In laboratory animals there is a control, because the other extremity is about normal. In children that is rarely true, so that accurate statistical results are very hard to produce.

Errors in technique in children are easy to correct, as compared with those in small animals, if the cases are observed closely. Actually we do not encounter the difficulty of trauma to the epiphyseal plate. Those of you who have used staples have observed that they can be placed very accurately, so as to straddle the

(*Continued on page 350*)

ROCKER-FOOT DUE TO CONGENITAL SUBLUXATION OF THE TALUS

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McMurray defined this entity as a condition in which the sole of the foot is convex because the heel is in equinus; the fore part is in a variable amount of extension and valgus, so that the most prominent part of the sole is formed by the head of the talus. He called it congenital flat-foot. In the American literature[8], the term congenital flat-foot is applied to a mild depression of the longitudinal arch, which is thought to have existed since birth. On the continent of Europe, the term rocker-foot is used for the condition under discussion.

The pathological changes associated with this deformity are best appreciated from a study of roentgenograms (Fig. 2-A). The keystone of the deformity is the talus. It points downward into the sole of the foot, its long axis being nearly a continuation (175 degrees) of that of the tibia. The calcaneus is carried into equinus with the talus. This deformity causes a break in the alignment of the tarsal bones at the mid-tarsal joint, so that the navicular does not articulate with the head of the talus, but faces the dorsal surface of its neck. The cuboid lies somewhat above the calcaneus, the plantar half of its posterior end being atrophied and compressed because of pressure stresses. The general appearance is not unlike a rocker; hence, the term "rocker-foot" is frequently seen. An excellent summary of the literature was presented by Lamy and Weissman in 1939.

Joachimsthal estimated that this condition constituted 4.3 per cent. of all deformities of the feet. Sonnenburg saw 688 cases of congenital club-foot, 42 cases of flat-foot, and 15 cases of congenital convex pes valgus or "rocker-bottom" foot. In the period between 1932 and 1941, twelve patients (eighteen cases of rocker-foot) were seen. This condition should be diagnosed as early as possible, as its treatment is difficult in an older individual. It is not until adult life that symptoms develop. None of the patients in this group presented themselves because of symptoms. They were either sent by a nurse or because the family was concerned about the appearance of the feet.

Etiologically, there are two points of interest in this series. One is the multiplicity of deformities. Four patients had more or less extensive contractures (of the type known as arthrogryposis multiplex congenita); two of them required surgery about the hips and knees to overcome contractures. One patient had congenital nasal obstruction; another had contractures of the palms; one had absence of the sacrum with sensory changes in the extremities. The last patient also had unilateral club-foot.

The other point of interest is that there was but one case of spina bifida in the series. Many writers are of the opinion that spina bifida is the causative factor in rocker-foot. The author believes that spina bifida is only one manifestation of a developmental disturbance which may include rocker-foot as well as other deformities. In two of the cases club-foot was present originally; due to mistreatment, rocker-foot developed. Thus one might say that rocker-foot is both congenital and acquired.

The treatment may be divided into conservative and surgical types. McMurray stated that, if corrective casts are applied in infancy, the condition can be improved but not completely corrected. The author has noted improvement in the general appearance of the foot, but roentgenograms reveal little, if any, change in the position of the bones. Surgical treatment, on the other hand, offers more chance of success.

Two types of surgical procedures are recommended: (1) astragalectomy, which seems to be the choice of most writers; and (2) removal of the head of the talus, as first discussed by Lange. In his first operative case in 1928, the author followed Lange's procedure of

removing the head and neck of the talus, so that the convexity of the sole could be corrected, and then grafting the head to the so-called anterior end of the body of the talus. The end result was good. This procedure was not repeated in subsequent cases, as the author was not certain of the potential growth of the grafted head. However, time has proved this method to be satisfactory.

The cases with which this report is concerned were treated by still another method between the years 1936 and 1941. When we consider that a rocker-foot contains two major deformities—moderately severe equinus and dislocation in the mid-tarsal joint—the operative treatment must be designed to correct each defect. The equinus of the hind part of the foot is corrected first. This deformity is to a certain extent masked, and becomes fully apparent only with the aid of roentgenograms. From a study of the foot, one might conclude that a simple plastic lengthening of the tendo achillis is sufficient and that the heel can forthwith be pulled into a satisfactory position. Since the fore part of the foot in this condition is not available as a lever, the heel can only be held down by skeletal traction after the tendon lengthening; in most instances, therefore, we have used a Kirschner wire or Steinmann pin, placed over the top of the calcaneus instead of through it. In older patients, it is also necessary to cut the posterior portion of the capsule across the tibiotalar joint, in order to release this tight structure and gain sufficient calcaneus of the hind part of the foot.

The mid-tarsal dislocation and the dorsiflexion contracture of the fore part of the foot are next corrected. This may be done through one of two approaches,—the Kocher approach, which is unsatisfactory as one has difficulty in closing the wound; or two longitudinal incisions, each about three inches in length. One is placed lateral to the extensor tendons over the sinus tarsi, and the other medial to the tibialis anterior tendon.

Upon approaching the deeper structures, one immediately becomes aware that the fasciae, tendons, and capsule are contracted sufficiently to prevent reduction of this dislocation. The tight fascial strands are teased out of the subcutaneous tissues and cut. Then the tendons of the tibialis anterior and the extensor hallucis longus are lengthened by means of a long step-cut or Z-plasty. Occasionally, the tibialis posterior and the flexor hallucus longus have to be lengthened, as well. Because the extensor tendons of the lesser toes are too thin and small to be lengthened, two alternating tendons are cut at the upper limit of the incision and the two remaining tendons are cut at the lower end of the wound. The long ends are sutured together and the short ends are sutured into the sides. This gives two tendons for the four toes traversing the incision. The capsules across the calcaneocuboid and the talonavicular joints are next cut. Occasionally, especially in older patients, it is necessary to cut the capsules of these joints on the plantar side as well. This can be done through the joint spaces, when all the tight structures on the dorsal aspect have been severed. With the aid of an elevator, the dislocation can then be reduced. Retention of position is difficult even after this extensive surgery, because there is enough tension in the skin and subcutaneous structures to prevent the fore part of the foot from being plantar-flexed enough to maintain reduction.

After all wounds have been closed, a cast is applied to the leg and thigh with the knee immobilized at a right angle. When the plaster has set over this part of the extremity, the heel is pulled into moderate calcaneus position by means of a pin over the calcaneus, anterior to the tendo achillis, and then is incorporated in the plaster. When this section of the cast has set, the fore part of the foot is manipulated and plantar-flexed to reduce the mid-tarsal dislocation, and is incorporated in the plaster. If one has sufficient help, the last two sections may be put on together. The cast, therefore, is applied in two or three sections, depending upon the available assistance. If resulting circulatory embarrassment prevents placing the fore part of the foot in adequate plantar flexion, the fore part of the cast should be changed, with the patient under anaesthesia, every four or five days as the circulation improves, until adequate reduction and plantar flexion of the fore part of the

foot have been obtained. If there is considerable tension at the talonavicular joint, a Kirschner wire may be inserted through the navicular into the head of the talus, protruding through the skin and cast so that it can be removed in three weeks. This step obviates the necessity for extreme plantar flexion of the fore part of the foot, and reduces the hazard of tissue sloughing, which happened in one case. The resultant scar bound down the tendons, so that the patient lost the power to dorsiflex the toes.

The thigh portion of the cast and the calcaneal pin are removed in six weeks, and the patient is allowed to bear weight, provided the cast is well molded in the arch. Total immobilization for four months is usually sufficient. The patient then should be instructed in foot exercises. None of the patients were given physical therapy, although this type of after-care would have been highly beneficial.

The following are brief summaries of some of the cases:

A. K., a girl of twelve, came to the University of Illinois Clinic in 1938 because of an abnormal gait. Both hips lacked 30 degrees of complete extension. The knees were contracted about 30 degrees. The feet had the characteristic rocker appearance; the tali pointed downward, making an angle of 175 degrees with the shaft of the tibiae.

The deformities in both feet were corrected by the technique described. In July 1945, the patient had no complaints after an average amount of walking; on long trips she became tired. Practically no pronation or supination was possible in the ankles. The right dorsiflexed to 75 degrees and the left to 60 degrees; plantar flexion was somewhat limited.

H. K., aged ten, the brother of A. K., came to the Clinic at the same time with the history of having had abnormalities of his feet since birth. He had the same arthrogrypotic appearance as his sister, and extreme rocker-foot deformity (Fig. 1-A). He was able to walk fairly well. The hip and knee contractures were corrected.

Both feet were operated upon,—the right in June 1938, the left in January 1939 (Fig. 1-B). In January 1945, the record states that the result was good and the patient was working as a farmer. He could walk on tiptoe and on his heels. Plantar flexion of the toes was excellent; dorsiflexion was good. A slight degree of pronation and supination was possible; plantar flexion and dorsiflexion of the ankle were good.

FIG. 1-A

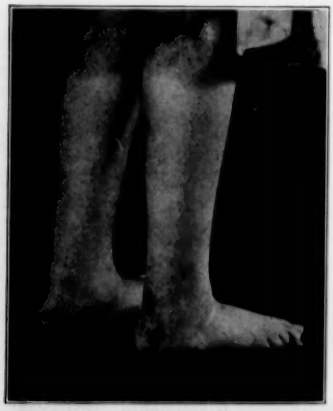

FIG. 1-B

Fig. 1-A: H. K. Preoperative photograph of a ten-year-old boy. The scars on the left thigh are the result of a burn in childhood.

1: Position of the heel.

Fig. 1-B: Postoperative photograph. Seven years after operation, the patient was doing a full day's work without any foot symptoms; he had no calluses on the soles of the feet, could walk on the heels and on tiptoe, and had a total range of pronation and supination of about 20 degrees.

G. W., a girl, aged four, was brought to the University of Illinois Clinic in August 1939, because the appearance of her feet had been abnormal since birth. On examination she presented the appearance of typical rocker-foot (Fig. 2-A). The deformity in the right foot was corrected in August 1939, that in the left foot in January 1940 (Fig. 2-B). The postoperative course of the right foot was uneventful. The epidermis sloughed on the left and, in the process of healing, the dorsiflexor tendons became adherent to the scar. The child was seen in August 1941, at which time she had moderate ankle valgus, and active flexion and extension of all toes of the right foot. The right great toe was in moderate valgus; the dorsiflexors of the left toes did not function. She could stand on tiptoe and could walk on the right heel, but could not dorsiflex the left foot enough to walk on the heel. The results ten years after operation are shown in Figures 2-C and 2-D.

M. J., a girl, aged four, entered the University of Illinois Clinic in 1938 because her gait was becoming poor and she stumbled frequently. Her appearance was that of mild arthrogryposis multiplex congenita. The right hip was dislocated anteriorly and typical rocker-foot deformity was present in each foot. The deformity on the left was corrected in March 1938, the Kocher incision being used for the fore part of the foot. A mild infection followed this operation. The deformity in the right foot was corrected in July 1939, one long medial incision being employed for the fore part of the foot. When the patient was last seen, in 1948, she walked with a limp on the right. The right foot did not appear deformed. The left heel was in slight varus and the fore part of the foot was moderately adducted. The great toe was in 40 degrees of valgus; its long extensor was active and seemed to aggravate the deformity. The subtalar joint had fused. She walked well and the dorsiflexors of all toes were active.

D. R., a boy of twelve years, entered the University of Illinois Clinic in December 1941, with the history that he had had operations for club-foot at two months and ten months of age. The nature of the surgery was not clear. Roentgenograms (Fig. 3-A) showed the talus to be at an angle of 170 degrees with the tibia. The appearance was so typical of rocker-foot that it was difficult to believe this once had been a club-foot. The tendo achillis was lengthened, but section of the posterior portion of the capsule was not done. (Each time the author has left the posterior portion of the capsule intact, the correction has been incomplete.) The dislocation of the fore part of the foot was treated in the usual manner through two incisions (Fig. 3-B). When the patient was seen in October 1945, he still had a slight rocker-foot deformity and slight contracture of the tibialis anterior. Dorsiflexion of the toes was good. He had no complaints.

R. H., a two-year-old boy, was brought to the Clinic in July 1938, with bilateral club-foot of moderate severity. Casts were applied, and were changed at two-week intervals. Early in 1939 it became apparent that moderately severe, typical rocker-foot was developing. Since there was moderate equinus of the talus (about 145 degrees), only a lengthening of the tendo achillis and posterior capsulotomy were done. A pin was used over the calcaneus, but the fore parts of the feet did not plantar-flex at the mid-tarsal joints. Correction was incomplete.

This case is summarized to emphasize that both deformities must be corrected. It was thought that the dorsiflexion of the fore part of the foot was mild and that stretching might occur without surgical interference, but incomplete correction resulted.

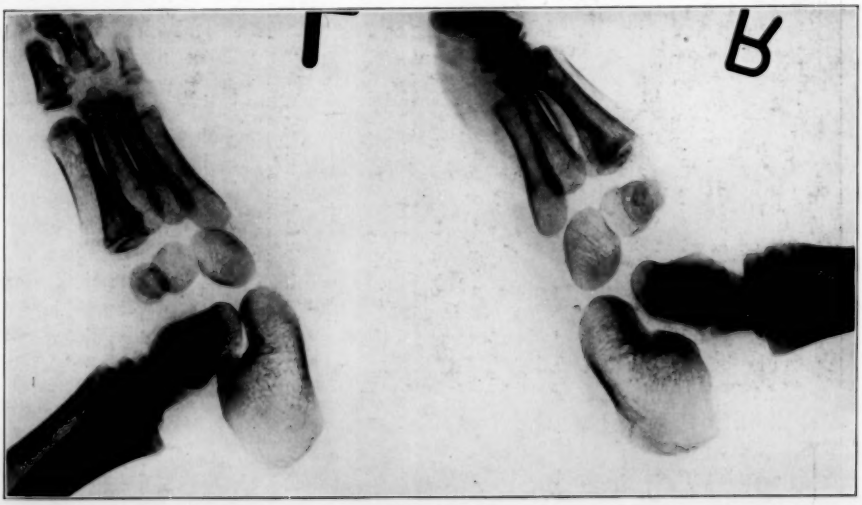

FIG. 2-A

FIG. 2-B

Fig. 2-A: Case G. W. In each foot, the head of the talus points directly toward the sole, its axis a direct continuation of the shaft of the tibia.

Fig. 2-B: Postoperative view of the left foot. The navicular has ossified since the preoperative roentgenogram was taken.

Figs. 2-C and 2-D: Ten years after operation, there is deformity of the head of the talus and the navicular of the right foot (Fig. 2-D). The left foot (Fig. 2-C) shows fusion in the subtalar and calcaneocuboid joints. There is no information as to whether the navicular is fused with the talus or whether it is absent.

FIG. 2-C

FIG. 2-D

DISCUSSION

Rocker-foot is a troublesome deformity, usually part of a group of congenital anomalies. It may, however, result from improper treatment of club-foot. The condition is best controlled by surgical procedures. The methods discussed in the literature sacrifice all or part of the talus to obtain correction. In this paper a technique is described for correcting rocker-foot by either sectioning or reconstructing the soft tissues. Eight congenital deformities and one case of secondary rocker-foot in which the talus pointed downward in the range between 175 and 180 degrees were treated by this technique.

FIG. 3-A

FIG. 3-B

D. R. Preoperative and postoperative roentgenograms.

Plantar flexion and dorsiflexion of the tibiotalar joint were good in all cases, as this joint is not disturbed. Plantar flexion and dorsiflexion of the toes were active in all but two cases. In one case there was sloughing of the skin over the dorsal surface of the foot. In the process of healing, the tendons became adherent. In one case, in which infection developed, most of the correction was lost and the tendons became adherent. Pronation and supination varied from 0 to 10 or 15 degrees; however, the gait was greatly improved, being more elastic. The so-called board-like gait disappeared; a few of the patients walked on their heels and on tiptoe. The cosmetic appearance was greatly improved.

Two cases of secondary rocker-foot deformity were treated by a modified technique, resulting in incomplete correction of the deformity.

The complications occurred in the youngest patients, so that the risks should be weighed carefully in children under five or six years of age.

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DISCUSSION

RESTRICTION OF BONE GROWTH

(*Continued from page 343*)

epiphyseal cartilage. In contradistinction to the present experiment, there is no piercing of the epiphysis by metal. The staples do not even touch the epiphyseal plate unless they are buried under periosteum, and this is rarely necessary.

I noticed in the pictures, which I saw today for the first time, that the crossed wires frequently protrude a great deal. I should like to ask Dr. Haas if the small animals run around as freely afterward as they did before. Children promptly start walking in a normal manner, so that the atrophy of disuse is not a factor. I should also like to ask Dr. Haas if there is sometimes penetration of the skin.

It is difficult to see why a single pin, protruding through the epiphysis, would cause such profound arrestment. Again I should say, as Dr. Philip Wilson said on Thursday: "You can't tell too much from experiments with small animals as to the effects on children".

I hope that Dr. Haas and others will continue this search, which will eventually produce an ideal method of correcting linear and angular deformity in growing children. At the present time, I consider that stapling is satisfactory. The new methods must each be tested clinically for a considerable number of years before the superiority of one of them can be accepted.

DR. WILLIAM T. GREEN, BOSTON, MASSACHUSETTS: We are all grateful to Dr. Haas not only for this work, but also for his past work on bone growth. Certain observations that we have made on animals, I believe, are pertinent to this discussion.

In repeated experiments on the rabbit, longitudinal nailing of femoral epiphyses through the plate and across the metaphysis did not produce shortening of the extremity. This nailing was through the central portion, and the animals were observed until maturity. On the other hand, if screws were used rather than nails, growth was inhibited. Apparently the screws produce enough anchorage on the two sides of the plate to exert compression upon it and thus inhibit growth.

If you associate this finding with the experiments of Dr. Haas, the results of which he showed today, it can be deduced that the inhibition of growth arises from a compression force which is produced by the cross-nailing and cross-pinning.

When we restrict the growth of the epiphysis for a period by compression, there remains considerable doubt as to how dependably growth will return when the staples or other compression forces have been removed. When stapling, for example, is practised to inhibit growth of the epiphysis in the human temporarily, one must always consider what the effect on length will be if growth is not resumed. This certainly must be the attitude until more information is available regarding the resumption of growth under such circumstances.

DR. S. L. HAAS (closing): I wish to thank Dr. Blount and Dr. Green for their discussion of this paper.

With the use of a wire loop or pins which anchored only a small portion of the plate on one side, it was uniformly observed that there was a restriction of growth on the opposite side. This is in conformity with the results observed with the use of staples. It is, therefore, considered worth while to keep this point in mind in the clinical application and to make careful studies over a long growth period.

As regards function after these operations, the animals were allowed free use of the limb without any restricting dressing on the extremity.

It is believed that the results obtained in the animal experiments can be relied upon, since the original observations on restriction of growth by the wire loop were developed from operations upon animals. The results of these experiments have led to the practical application in humans, and have opened up an interesting field for further investigation of some of the problems on restriction of growth.

CORRECTION OF DEFORMITY AND PREVENTION OF ASEPTIC NECROSIS IN LATE CASES OF SLIPPED FEMORAL EPIPHYSIS *

BY CLINTON L. COMPERE, M.D., CHICAGO, ILLINOIS

From the Department of Bone and Joint Surgery, Northwestern University Medical School, and the Departments of Orthopaedic Surgery of Wesley Memorial and Chicago Memorial Hospitals, Chicago

Treatment of displacement of the capital femoral epiphysis has been a controversial subject for many years. The late end results of treatment have been discouraging. Open surgical treatment for progressive or old displacement of the femoral head has been recommended by an increasing number of surgeons. Most of the literature dealing with the subject merely designates the type of operation and enumerates or tabulates the end results. Experience has convinced the author that each step in a carefully planned surgical technique and in the after-care is of the utmost importance. The operation may be easy to perform in a rough and careless manner, with grave trauma to soft tissues, blood supply, and bone; it is a difficult procedure, when carried out with proper attention to details that will protect the circulation and promote a really satisfactory end result.

Closed internal fixation in the stage before apparent displacement or for minimal slipping of the capital femoral epiphysis has become the method of choice of most orthopaedic surgeons. There is agreement among experienced surgeons that reduction of the displaced femoral head by forceful manipulation should be avoided. In the majority of cases, no improvement in position is obtained, and the trauma may further reduce the circulation to the femoral head and result in aseptic necrosis, collapse of the head of the femur, painful coxitis, or ankylosis.

Surgical correction of the primary deformity has been described by Wilson, Martin, Key, Kleinberg and Buchman, Howorth, Badgley and his associates, Ghormley and

TABLE I

METHODS OF TREATMENT USED FROM 1942 TO 1949

Treatment	No. of Patients	No. of Hips
Open operation	18	20
Closed reduction—internal fixation	12	16
Subtrochanteric osteotomy	5	5
Miscellaneous non-surgical methods (cast, traction, protection, et cetera)	10	12
Arthroplasty	1	1
Total	46	54

Fairchild, Klein and his associates, and Green. The details of the operative technique have not been emphasized in any paper advocating open reduction and wedge resection of the neck of the femur for the treatment of old or progressive epiphysiolysis with marked deformity. No step in the operative technique is original. An effort has been made to determine which factors were essential for a high incidence of good end results. These details of operative technique have been followed carefully in the treatment of a small series of cases, with more satisfactory results than had been obtained previously.

In recent years, orthopaedic surgeons have become cognizant of the advantage of

* Read at the Annual Meeting of The American Orthopaedic Association, Colorado Springs, Colorado, May 18, 1949.

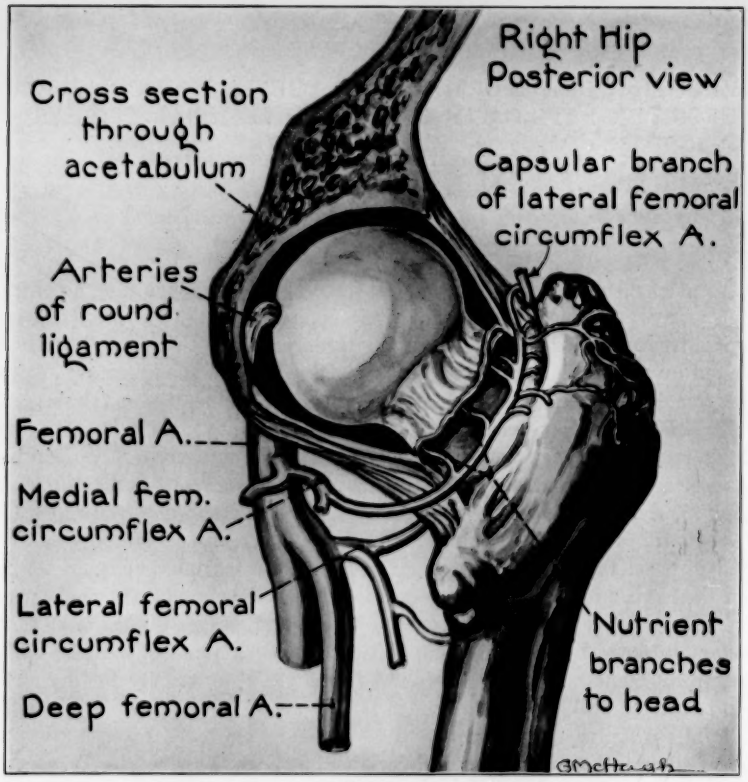

FIG. 1

Drawing of the normal blood supply of the head of the femur. In severe displacement, the anterior-superior nutrient vessels to the head will be torn; the more important posterior and inferior vessels may be intact. (Reproduced from *Pictorial Handbook of Fracture Treatment*, Chicago, 1943. By permission of The Year Book Publishers, Inc.)

pinning fractured hips in a position of moderate valgus. However, descriptions of the open operations for slipped femoral epiphysis recommended by various surgeons place little emphasis on *overcorrection* of the deformity, although roentgenograms of many of the

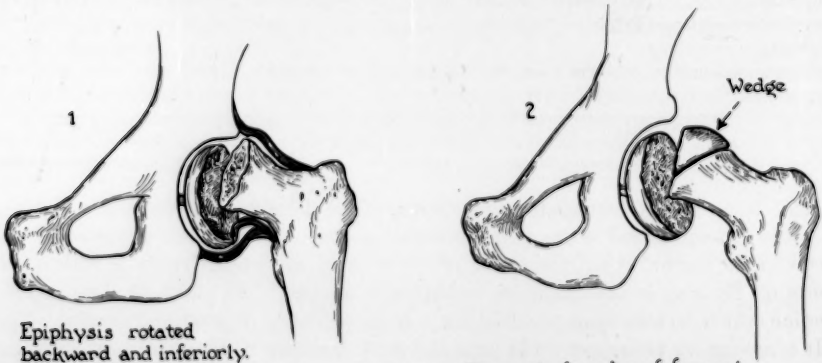
1
2
Wedge
Epiphysis rotated backward and inferiorly. Femoral shaft displaced upward with resulting shortening of the leg.
Removal of wedge of femoral neck.

FIG. 2

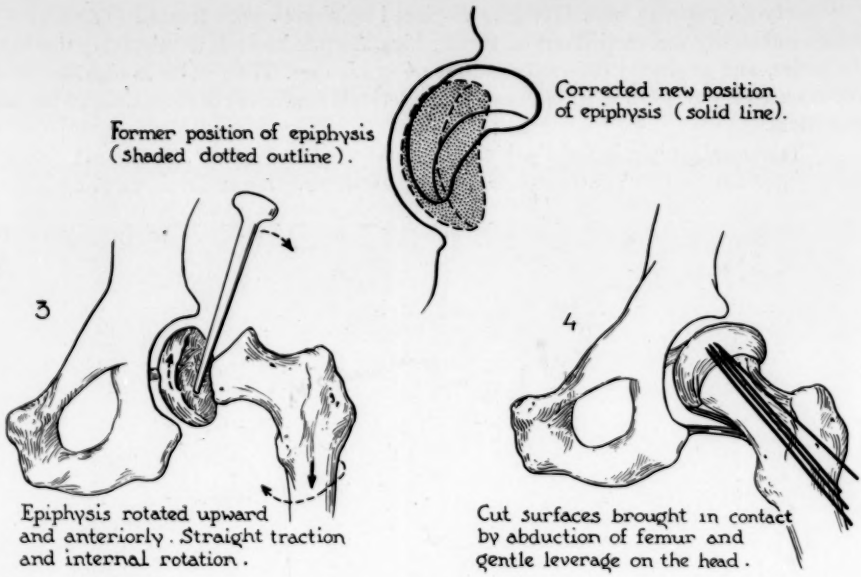

FIG. 3

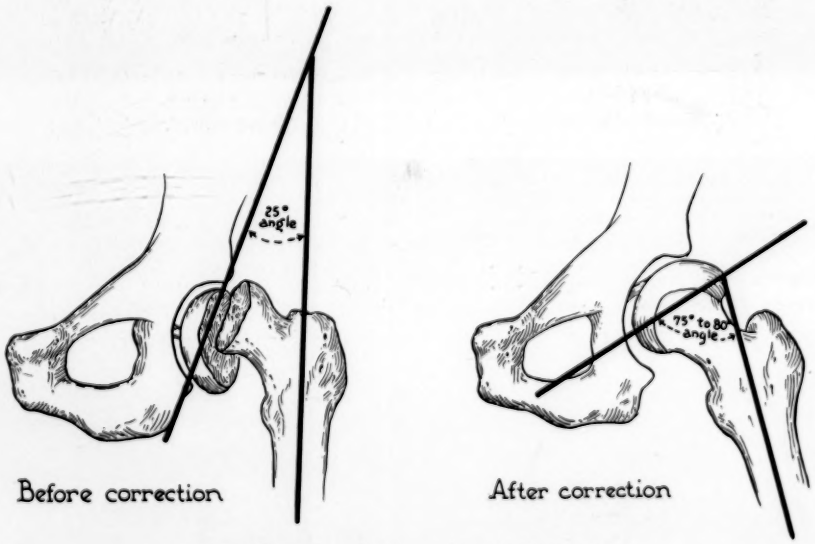

FIG. 4

patients of Martin, Badgley, and Klein and his associates demonstrate that this over-correction was associated with excellent functional results.

It is not the purpose of this paper to discuss the diagnosis, etiology, or late end results of epiphysiolysis. The wish is expressed that others will try the wedge resection, and that the detailed description of each step in the operative technique and after-care will be of value to those who have had no experience with this procedure. The technical routine has been evolved from close association with William J. Schnute and Edward L. Compere.

Forty-six patients with fifty-four displaced epiphyses were treated (Table I). The wedge osteotomy was carried out on twenty hips. Aseptic necrosis developed in one hip of the series, and moderate deformity is present in another. The results in eighteen of the twenty are very gratifying, with an average functional coefficient of more than 90 per cent. of normal.

The normal circulation of the hip is demonstrated in Figure 1. The blood vessels in the retinaculum or reflected capsule along the inferior portion of the femoral neck are of

FIG. 5-A
September 10, 1945

FIG. 5-B
September 10, 1945

FIG. 5-C
April 28, 1949

FIG. 5-D
April 28, 1949

W. K., aged thirteen, had had progressive disability for six months. Operation was performed on September 24, 1945. By April 29, 1949, the patient was free of clinical complaint, had no pain or limp, and was engaging in athletics. The head was viable. There was one-half inch of shortening.

vital importance. The contribution of the small vessels of the ligamentum teres to the oxidation and nutrition of the head of the femur varies with each patient, as Chandler and others have demonstrated.

The surgical incision for the approach to the hip-joint capsule should be planned so that it will produce minimal interference with early, active use of the hip after operation.

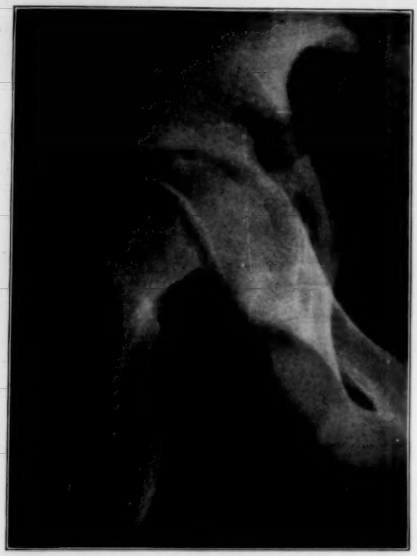

FIG. 6-A
March 15, 1946

FIG. 6-B
July 16, 1946

D. K., aged fifteen, a brother of W. K., had had progressive disability for seven months before operation on March 27, 1946. Fig. 6-B shows advanced healing at four months, with the head in the desired position.

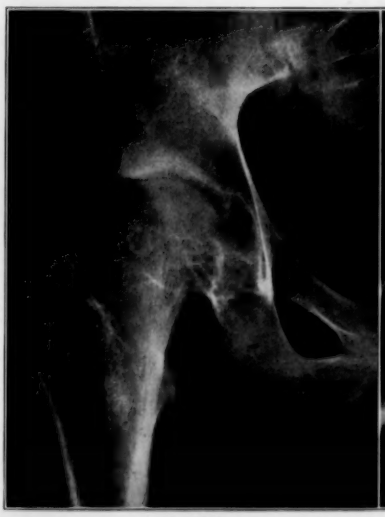

FIG. 6-C
April 28, 1949

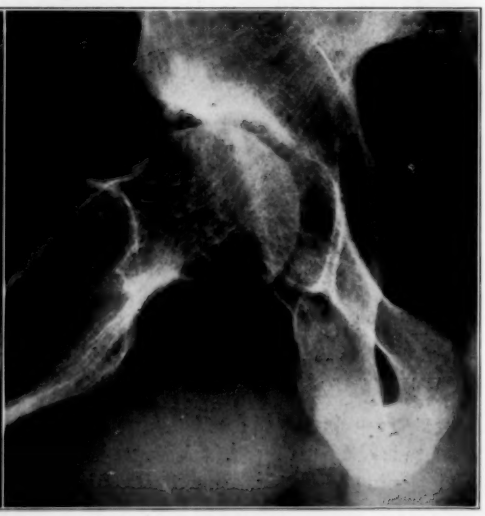

FIG. 6-D
April 28, 1949

Show slight sclerosis of the acetabulum, with a viable head and good joint space. There was no pain or limp, no shortening, and no complaints.

FIG. 7-A
June 28, 1946

FIG. 7-B
July 12, 1946

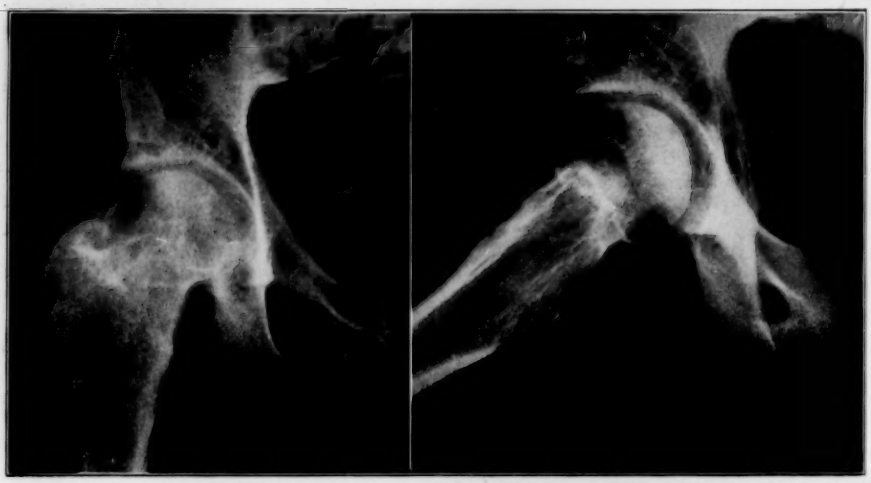

FIG. 7-C
June 30, 1949

FIG. 7-D
June 30, 1949

W. O., aged thirteen, had had progressive disability for thirteen months. He could not bear weight on his extremity and spent most of the time in bed. Marked bone and muscle atrophy were present in the involved side. Fig. 7-B shows overcorrection, with the line of stress changed to a right angle. The patient has one-half inch of shortening, and walks with only a slight limp. There is no pain and practically a normal range of motion.

Adequate exposure can be obtained without stripping the gluteal muscles from the ilium. Exposure is obtained by an incision which begins just posterior and lateral to the anterior superior spine of the ilium and passes between the tensor fasciae latae and the rectus femoris. The reflected head of the rectus is separated from the ilium, and the tendinous portion of the tensor is divided transversely, below the greater trochanter. The capsule is incised anteriorly, from its attachment to the ilium above the hip joint, and distally, parallel to the femoral neck. By means of a wide osteotome, a wedge, two centimeters

FIG. 8-A
August 19, 1946

FIG. 8-B
August 19, 1946

wide at the base, is removed from the superior surface of the femoral neck, distal to, but reaching, the epiphyseal line (Fig. 2). The removal of the wedge affords better visualization, and the epiphysis may then be completely freed with a minimum of trauma, by means of a thin elevator or osteotome.

Great care should be used to avoid injury to the posterior capsular attachments, through which the blood supply must reach the head of the femur, if aseptic necrosis is to be avoided. A narrow bone gouge should be used to break through fibrous and cartilaginous tissue on the head fragment, exposing the compact cancellous bone of the head. If this is not accomplished, the epiphyseal plate may delay union by obstructing the ingrowth of vascular tissue from the neck. The femoral head is lifted up onto the neck as straight traction is applied to the femur (Fig. 3). When a satisfactory valgus position has been obtained, the femur is internally rotated and moderately abducted about 30 degrees.

FIG. 8-C
November 8, 1946

It may be necessary to stabilize the relatively loose head with a bone punch or elevator while the extremity is being manipulated. When the head rests on the raw bone of the neck in a position of valgus, there will be no sheering stress on the line of healing. Threaded wires, inserted through the trochanter, neck, and into the femoral head, have been found to be a most satisfactory and atraumatic means of obtaining immobilization (Fig. 3).

When the resection has been carried out properly, the line of sheering stress will have been changed from vertical to horizontal (Fig. 4). This is a most important factor in the plan of treatment; if ignored, the operation will not yield good results.

Preoperative and postoperative roentgenograms of five patients treated in the manner described are shown in Figures 5-A to 9-F, inclusive.

FIG. 8-D
August 27, 1948

FIG. 8-E
August 27, 1948

R. E., aged fourteen, had a history of disability for four months. Excellent overcorrection and rapid healing were obtained. The threaded pins should have been removed approximately six months after the original operation. In this instance removal was delayed for sixteen months; two pins broke, flush with the bone, and were left in place. The head is viable with a small ridge of bone superiorly and laterally. The patient has painless function, engages in athletics, and has no limp.

Postoperatively, the patients are placed in Buck's traction for a few days; then they are allowed to be ambulatory with crutches. They are not permitted to bear weight until union has been demonstrated by roentgenogram. This usually requires about three months; if there is a question as to the viability of the head, weight-bearing should be further delayed.

FIG. 9-A
June 9, 1948

FIG. 9-B
June 9, 1948

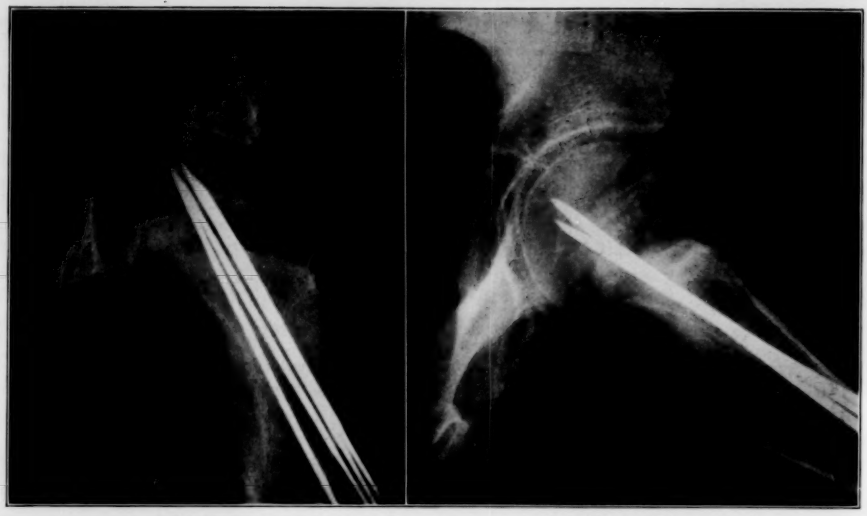

FIG. 9-C
July 12, 1948

FIG. 9-D
July 12, 1948

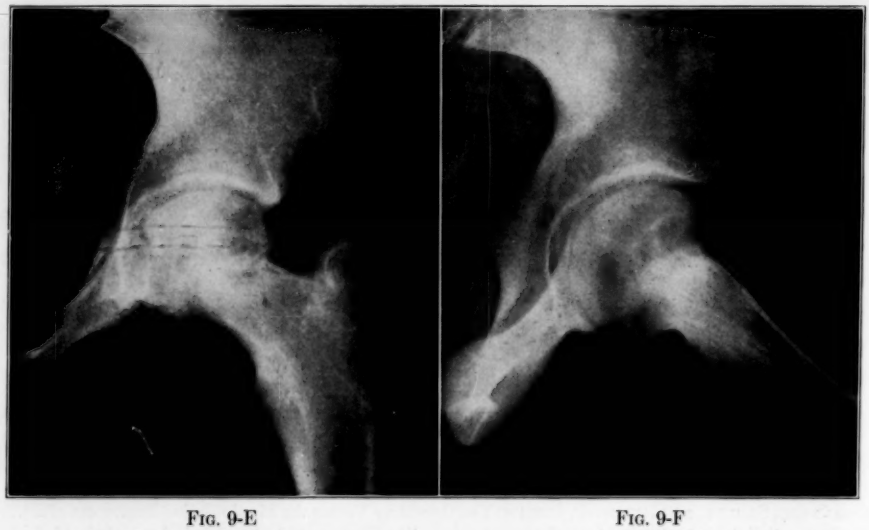

FIG. 9-E
April 12, 1949

FIG. 9-F
April 12, 1949

H. P., aged fifteen, had had progressive disability for four months. The lateral roentgenogram demonstrates a more severe displacement than is obvious from the anteroposterior view, taken in external rotation. Fig. 9-C shows excellent position, with more of the superior portion of the neck removed than was necessary. This apparent defect filled in readily. The end result shows a viable head with normal contour and excellent joint space. There is no limp or pain, and clinically the hip is normal at this early date.

CONCLUSIONS

1. The object of treatment of slipped or slipping capital femoral epiphysis is to maintain or restore painless hip function, with a range of motion as nearly normal as possible and a minimum of shortening of the extremity.

2. Epiphysiolysis with marked displacement has been treated by open wedge osteotomy with uniformly good results. Aseptic necrosis with osteo-arthritis occurs rarely. The

incidence is definitely less than that which follows closed manipulation, and is no greater than that which follows application of a cast without any attempt at reduction.

3. An accurate determination of the degree of slipping is essential. This is possible only with good lateral roentgenograms of the hip.

4. To avoid aseptic necrosis or delayed osteo-arthritis, there must be a minimal amount of damage to the blood supply when the capsule is opened to expose the joint.

5. Wedge resection of the proximal superior portion of the femoral neck should be followed by gentle freeing of the head, just distal to the epiphyseal line.

6. The epiphyseal plate must be perforated with a gouge and a curette, thus exposing porous cancellous bone on the portion of the head which will be in contact with the prepared neck surface.

7. Great care should be exercised in the reduction to prevent additional injury to the circulation of the femoral head, as a result of needless stretching or tearing of the ligamentum teres or the capsular vessels. The head should be placed in position over the raw bone surface on the top of the neck.

8. Rigid internal fixation of the head of the femur to the neck is essential.

9. Early active motion is most desirable, with the hip protected from weight-bearing until healing is complete.

10. If the follow-up roentgenograms show aseptic necrosis, weight-bearing should be postponed until there is roentgenographic evidence of replacement of the dead bone by creeping substitution.

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DISCUSSION

Dr. C. Leslie Mitchell, Detroit, Michigan: Dr. Compere has brought to our attention some of the reasons for the high percentage of poor results obtained in the treatment of severe slipping of the upper femoral epiphysis. He also proposes methods of treatment to obviate such unfortunate results. We all know that in the past a great difference of opinion has existed among orthopaedic surgeons regarding the advisability of performing transcervical osteotomy for severe slipping. The earlier reports were extremely discour-

aging, because of the high percentage of cases in which avascular necrosis or traumatic arthritis developed. It would appear, however, that in the past few years an increasing number of reports give a high percentage of good and excellent results. My own experience with open reduction and transcervical osteotomy, performed on over twenty hips in the past twelve years, has convinced me that the procedure has merit. In our series we have had no cases of avascular necrosis and relatively few with traumatic arthritis.

Dr. Compere has made an attempt to account for the good results in his series. It is his theory that four factors are important,—namely (1) atraumatic surgery through a relatively small incision; (2) careful preservation of the blood supply in the posterior portion of the capsule; (3) proper placement of the head on the neck; and (4) removal of the epiphyseal plate. Granted that his results are good, are these the only reasons? Other surgeons have obtained equally good results with a more extensive operative exposure, without removing the epiphyseal plate.

Forcible manipulation in these cases has been condemned in the past few years. Can we account for the higher proportion of poor results in the past, when the patients were treated by open operation, on the basis that many of the cases had had preliminary unsuccessful attempts at closed reduction which, rather than the surgical procedure itself, jeopardized the vascularity of the head?

Improved operative technique, particular care being taken not to interfere with the blood supply in the posterior portion of the capsule, may also account for the improvement in results. Almost all observers reporting good results have emphasized this point.

I doubt if the surgical approach to the hip joint is of major importance in the preservation of the vascularity of the head. Dr. Badgley, in accounting for the good results in his series, emphasized the importance of adequate exposure and recommended the approach originally designed by Smith-Petersen for acetabuloplasty. In our cases, we have used the orthodox Smith-Petersen approach.

Dr. Compere has emphasized the importance of accurate apposition of the head on the neck, with some overcorrection to produce a valgus position. This would appear to be desirable. In reviewing our series, after receiving Dr. Compere's paper, I found that the best results occurred in those cases where this had been done.

The method of pinning the head after osteotomy does not appear to be a factor in influencing end results. Multiple pins would appear to cause less trauma and there might be less danger of distraction; but again, speaking from personal experience, we have routinely used the Smith-Petersen nail with no apparent untoward results.

Another factor which may be of importance, and which perhaps was not stressed sufficiently in Dr. Compere's paper, is early ambulation. He used traction for only a few days after surgery, and then allowed the patient to be ambulatory with crutches, but no weight-bearing on the affected extremity was permitted until union was solid.

Dr. M. Beckett Howorth, New York, N. Y.: A few points are worth mentioning. One is the technique of the operation, which has been well described and with which I agree completely. Our technique at the Orthopaedic Hospital has been very similar.

The second point is the evaluation of the results. Men vary a great deal in the standards which they set up. One of the cases which Dr. Compere presented, I thought did show considerable change in the head and thinning of the joint space. We were as enthusiastic as Dr. Compere when we started doing these open operations, over twenty years ago. However, a twenty-year follow-up on many of the cases has been discouraging. When we compared the operative results with the results in untreated cases, we found that nature, even in the presence of considerable slipping, did a better job in many cases than we had been able to do for the patient surgically. Osteo-arthritis resulted eventually in each group, but in the untreated cases it occurred at about the age of forty or forty-five, whereas in those patients who were operated upon, osteo-arthritis developed at the age of twenty or twenty-five. In quite a number, we had to do fusion or arthroplasty a few years after the open reduction.

Even with such a high quality of surgery as has been practised by Dr. Compere and the others who are now enthusiastic about the operation, we certainly need to follow these cases for a longer period of time and with a very high standard (I would consider the normal hip as the proper standard), before we can continue to be enthusiastic about this procedure.

Dr. Harold B. Boyd, Memphis, Tennessee: Dr. Compere has presented an excellent paper on a most important subject. Dr. Ingram, Dr. Bourkard, and I recently studied our patients at the Clinic and reported the findings at the annual meeting of the Southern Medical Association.

I agree that the operation should be done carefully and that every effort should be made to preserve the blood supply to the epiphysis. Pulling the epiphysis too far upward and forward on the osteotomized neck may stretch the postero-inferior portion of the capsule, thus partially strangulating the blood supply to the epiphysis. Even with a carefully done osteotomy, aseptic necrosis of the epiphysis may occur. If the epiphysis has slipped one third of the diameter of the head or less, the best and safest treatment we found was the insertion of three Knowles pins. These pins present some advantage over a three-flanged nail, and have been adequate to prevent further slipping of the epiphysis. In the patients treated with the pins and without

osteotomy, no case of aseptic necrosis of the epiphysis has resulted. In two cases in which the epiphysis had slipped approximately one half of the diameter of the neck, good results followed nailing of the epiphysis *in situ*. Some patients whose roentgenograms would suggest treatment by osteotomy may be treated successfully by a simpler operation.

If the hip can be flexed to 90 degrees without externally rotating the thigh, we believe that the patient can be treated without subjecting the hip to the hazards of an osteotomy of the neck of the femur. Such a patient will have a serviceable hip, despite the limitation of internal rotation.

In a small number of patients with arthritic changes and narrowing of the joint space, poor results were the rule, regardless of the type of treatment employed.

DR. EDWARD L. COMPERE, CHICAGO, ILLINOIS: The procedure which has been outlined and which we attempted to follow in exact detail was brought to our attention, with a few changes, by William J. Schnute, who joined our group in Chicago from Dr. Badgley's service in Ann Arbor. Most of the patients have been operated upon by Dr. Schnute and by Clinton Compere. The one bad result in our series of twenty hips occurred in a patient upon whom I operated. The reason for this case of aseptic necrosis may be that I did not do a good operation. I did not remove all of the epiphyseal plate. The patient was a large adolescent male; the operation was difficult; and I did not hollow out the head fragment adequately.

In these cases of old slipped epiphysis, the bone in the metaphyseal portion of the neck (that bone which is just distal to the epiphyseal line) appears to be avascular when cut. Only after removing the wedge (a most important part of the operation) do we expose bone that seems to have good vascularity. If, having removed the epiphyseal plate and some of the bone beneath it, we bring cancellous bone of the head into contact with cancellous bone of the neck, union occurs rapidly. Within six to eight weeks, roentgenograms show evidence of union between the head and the neck. Some of you may have obtained good results without removing the epiphyseal cartilage. However, I doubt if anyone here would argue that tissue should be left interposed between the fragments of a fracture merely because fractures occasionally heal in spite of such tissue. Certainly, the epiphyseal plate is a barrier which will delay union, and any delay may lead to further loss of vitality in the femoral head.

Early motion of the hip and activity on crutches within a few days after operation are also important considerations in the convalescent care of these patients.

DR. CLINTON L. COMPERE (closing): I have studied Dr. Howorth's results very carefully. He has certainly reported them in great detail from a statistical standpoint. I noted that in many of his earlier cases the hips were immobilized; we feel strongly that they should not be immobilized. In many of the later cases he used small, thin grafts inserted across the line; if I did that, I would also employ metal fixation and early mobilization.

I want to emphasize again, as was stated in the paper, that we are not claiming originality for any single new step in the technique. However, no one has really correlated the procedure, or set it forth so that one who had not assisted at the operation would know how to do it. That is really the purpose of this paper, and if the steps are followed, with maybe a few minor modifications as to incision and exposure, good results will be obtained. In many of our earlier cases the Smith-Petersen incision was used,—the complete incision. Later we found that we could obtain adequate exposure without removing the glutaeus muscles from the ilium. The patients move their hips earlier and better, and can be up on crutches within a few days.

LESIONS OF THE SUPRAPATELLAR PLICA *

BY GARRETT PIPKIN, M.D., KANSAS CITY, MISSOURI

From the Department of Orthopaedic Surgery, Temple University, Philadelphia

Disturbances of the suprapatellar portion of the synovial cavity of the knee joint have been described vaguely in surgical writings as "adhesions" (Fig. 1). This "adhesion" corresponds to a definite anatomical structure. The results of studies of the suprapatellar plica of the knee joint are presented.

The stratum synoviale of the knee joint is the largest and most elaborately arranged of its kind in the body. It lines the fibrous stratum of the capsule and forms a covering for the intracapsular ligaments and the free surface of the infrapatellar fat pad. The synovial stratum upon the surface of the fat pad forms a band which extends from the patella to the intercondylar notch, called the plica synovialis patellaris. At its femoral end it is narrow and attenuated, but at its patellar end it expands on each side to form winglike fringes. Apart from these special foldings, the synovial stratum lines the deep surface of the common extensor tendon and extends for a variable distance proximal to the patella. This extension of the articular cavity communicates with a large bursa, situated still more proximally on the front of the femur.

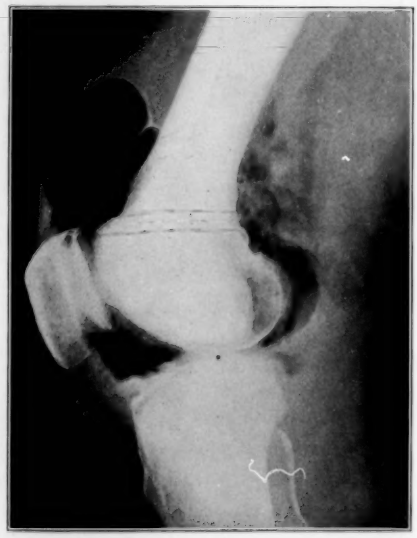

FIG. 1

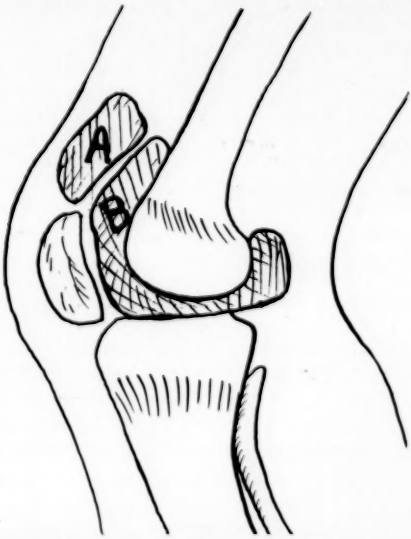

FIG. 2

Fig. 1: Condition inaccurately diagnosed as "chronic synovitis with adhesions".
Fig. 2: Showing the two compartments which make up the suprapatellar space:
A: The suprapatellar bursa. *B:* The suprapatellar synovial membrane.

In spite of the fact that anatomists recognize the suprapatellar bursa and comment upon its communication with the knee joint, it is common anatomical teaching that these two chambers are for all practical purposes one synovial space. Because of such teaching, the wide variations in shape imparted to the synovial cavity by its connection with the suprapatellar bursa have remained an anatomical curiosity (Fig. 2).

* Presented as a Scientific Exhibit at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 24 to 29, 1948.

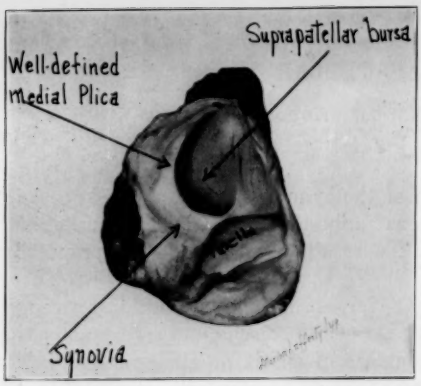

FIG. 3

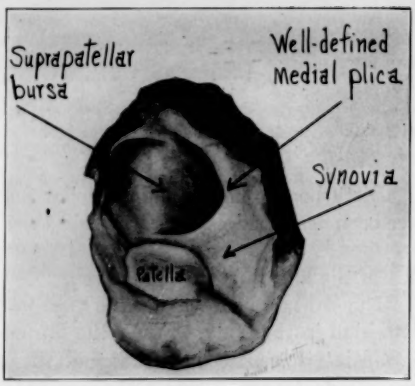

FIG. 4

Fig. 3: Common form of open communication in right knee of an adult. Dissection shows articular surface of patella and a postero-anterior view of quadriceps pouch.
Fig. 4: Common form of open communication in left knee of an adult.

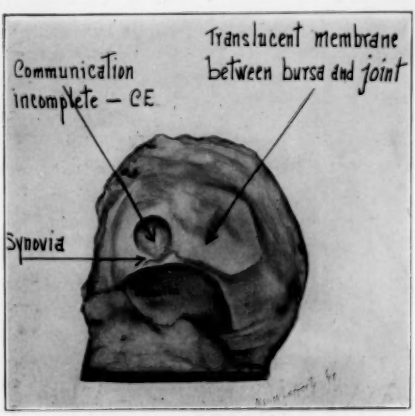

FIG. 5

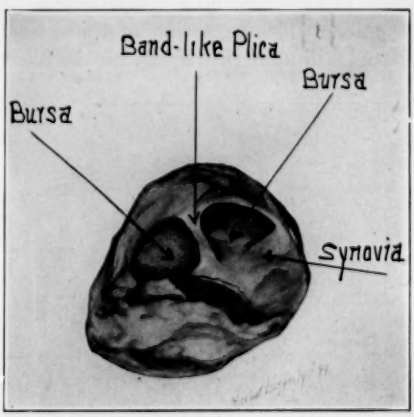

FIG. 6

Fig. 5: Showing bursa separate from right knee.
Fig. 6: Showing a normal variation,—a bandlike plica in right knee of adult.

Most textbooks contain little information concerning the shape and character of the suprapatellar bursa. In the German literature, ideas vary as to the cause of the communication between this bursa and the knee joint. All authorities agree that, in general, those bursae which develop later in life are caused by mechanical forces, such as pressure or friction. Hence, according to one school of thought, those bursae which are present at birth are the result of the same mechanical factors, causing a process of atrophy and resorption of intercellular tissue. Others believe that the deeply situated bursae are, just as the joints, originally planned organs. A third group believe that the suprapatellar bursa becomes continuous with the knee joint at the time of birth and enlarges thereafter [4, 5, 8, 11, 13, 14].

Hohlbaum examined 252 knee joints of persons of all ages, and concluded:

1. The suprapatellar bursa appears about the fourth month of foetal life.

2. A "perforation" of the suprapatellar bursa into the knee joint starts towards the end of the fifth month of prenatal life.

3. The cause for the different sizes and shapes of the "perforation" can best be explained by the mechanics of the joint, and by resulting differences in the relation of the quadriceps tendon to the surface of the condyles.

4. The most frequent finding is a broad communication, extending from the medial portion of the suprapatellar bursa to the lateral condyle, once in a while going even farther.

5. Communications occur in 78 per cent. of adult knees.

Communications between the bursa and the joint can almost always be identified by a synovial fold, which is especially prominent on the medial border. This fold is called the *suprapatellar plica.*

Anatomical dissections were performed on fresh postmortem material in which the knees were considered normal, so as to procure representative specimens (Figs. 3, 4, and 5). In all of these drawings the femur has been removed; one looks anteriorly at the articular surface of the patella, and cephalad into the hood of the suprapatellar pouch. In the undistended knee the fold (plica) rests upon the femur, so that the larger suprapatellar cavity is technically the bursa.

A completely separate bursa is shown in Figure 5. The area of condylar erosion (*C.E.*, Fig. 5) was produced by a degenerative fraying of the suprapatellar synovial membrane, not sufficient to establish a communication with the suprapatellar bursa. The bursa was completely separated from the joint by a thin, translucent membrane.

A bandlike medial plica is shown in Figure 6. The process of cellular pressure resorption from the femoral condyles has produced this congenital anomaly. A surgeon unfamiliar with this variation could easily call such a plica an "adhesion".

Pneumo-arthrography has provided a practical method of demonstrating the variations in the suprapatellar space. It follows as a corollary to our thesis that, if a separate bursa is not present, a plica must be, and proper soft-tissue studies in a pneumo-arthrogram will demonstrate it. Further, inflammatory reactions in the suprapatellar pouch (the suprapatellar pouch is defined as that area including both suprapatellar synovial membrane and bursa in open communication) will create an increased tissue density which will cause the plica to cast an increased shadow in the pneumo-arthrogram.

A series of 247 pneumo-arthrograms have been reviewed in an endeavor to establish some conception of a normal plica shadow. Some of the variations encountered are shown (Figs. 7 to 12). These have been graded as (1) an open communication, with no evidence

FIG. 7

A faint plica (normal).

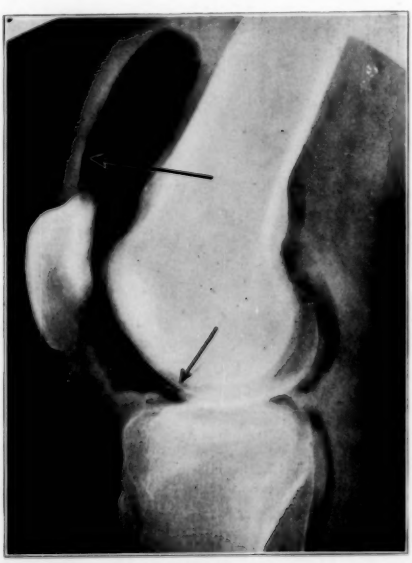

FIG. 8

Trace of plica (normal).

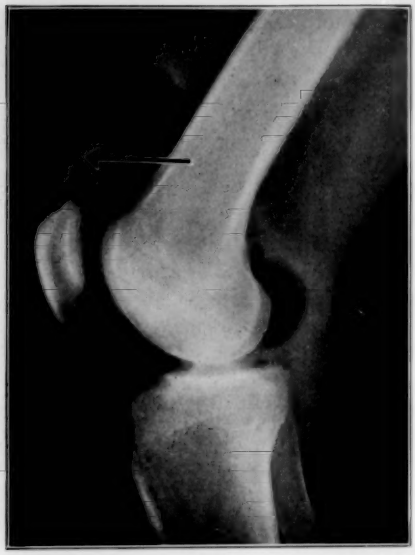

FIG. 9

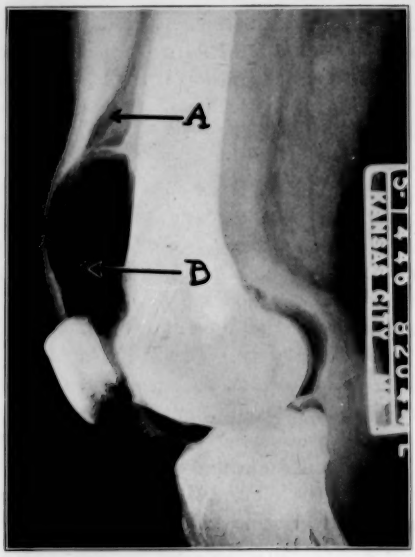

FIG. 10

Fig. 9: A moderate plica (normal).
Fig. 10: Variation considered normal: Fascial space (*A*) is visualized by over-distending bursa (*B*).

of a plica remaining between the suprapatellar bursa and the knee joint; (2) a moderate plica; (3) a distinct separating membrane, but with a communication; and (4) no communication. In the last instance the suprapatellar space appears abnormally small, because the portion ordinarily contributed to it by the bursa is not visualized (Fig. 12).

A thickened plica may in itself disturb knee mechanics. Figure 8 depicts a torn medial meniscus with a thick plica in a woman, twenty-two years old. This young woman

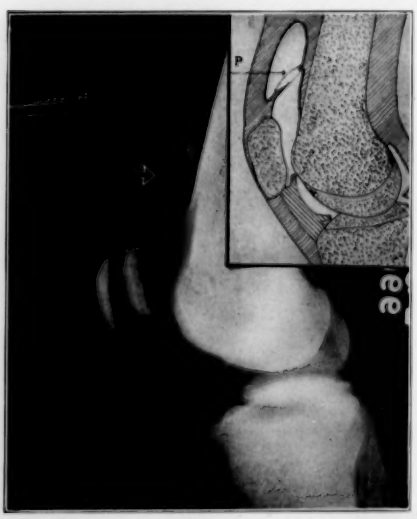

FIG. 11

FIG. 12

Fig. 11: Normal oblique: At 15 to 20 degrees from a true lateral, the hourglass shape of open communications casts an ovoid shadow.
Fig. 12: Bursa is separate (normal).

had delayed operation for several months, forcing use of a locked and puffy joint. Because of her thickened plica, we were able to prognosticate a secondary complicating synovitis and a much slower convalescence after meniscectomy. The plica was not removed. Convalescence required approximately six months. The function of the knee is excellent after three years. The injury can cause irreversible tissue changes, as will be shown later. The author feels that the majority of thickened plicae will become normal, if the underlying injury to the knee is eliminated.

The probable existence of a separate suprapatellar bursa is of surgical importance in the following circumstances:

1. In the management of penetrating wounds and acute suppurative bursitis, the surgeon may rupture the partitioning membrane and unnecessarily contaminate the knee joint [3, 15].

2. The surgeon exploring from an infrapatellar route may never locate rice bodies, when present (Fig. 13).

3. The bursa may have to be excised because of recurring non-specific bursitis [6, 7].

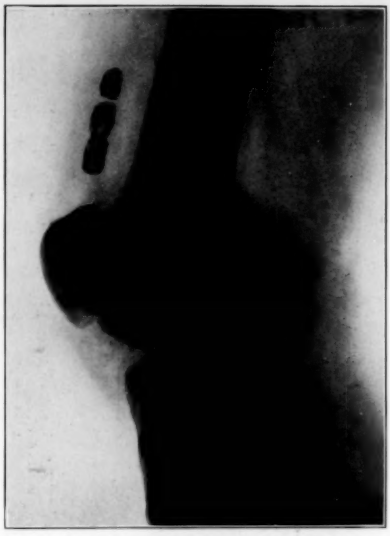

FIG. 13

Rice bodies appearing in separate bursa. (Presented by permission of Jesse Nicholson, M.D.)

4. Isolated hemorrhage, resulting in a persistent rubbery mass requiring excision, has been reported [1].

In cases of open communication, fibrosis, hyalinization, and calcification of the suprapatellar plica may produce recurrent mechanical disability of the knee, which simulates cartilage disability. A calcified suprapatellar plica in the first case is, as far as we can determine, the first of its kind to be reported.

CASE 1. W. P. a fireman, aged thirty-four, injured his left knee in 1941, when his hook and ladder hit a streetcar. Swelling of the knee was treated with hot packs and early motion. Aspiration was not done. The patient continued to complain of knee disability and refused to return to duty. He was referred in 1942 as a possible malingerer. His complaints were that his left knee "aches, pops, and goes down", followed by swelling. The symptoms were relieved by rest.

Physical findings during a quiescent phase showed normal motion, no swelling, and slight quadriceps atrophy. The patient pointed out that, if a finger were placed just above the medial border of the patella and the knee were flexed rapidly, an audible "pop" resulted, of sufficient force to displace the examining finger.

A pneumo-arthrographic diagnosis of calcified suprapatellar plica was made (Fig. 14) and partial synovectomy was done in 1942. Histopathological examination showed that the synovial membrane was calcified.

The patient returned to light duty in one month and to full duty in two months. At the end of five years he was on full duty as a fireman, with no complaints referable to his knee. He had three-quarters of an inch of atrophy and full motion.

CASE 2. H. W. M., a man, aged forty-three, was employed installing telephones. In 1933, while arising from the kneeling position, his left knee became "dislocated". Reduction was accomplished by a jerk. Similar episodes recurred on numerous occasions thereafter, followed by pain and swelling. Examination in 1939 revealed only slight tenderness along the medial side of the knee, above the patella.

A pneumo-arthrogram was reported as follows: "Synechia in the anterior fossa with slight hypertrophy of the fat pad. Some hypertrophic patellar spurs . . . sharpened spines." Partial synovectomy was performed on July 26, 1939, for suprapatellar adhesions. The pneumo-arthrograms were later destroyed at the hospital.

The histopathological findings were as follows: "Tissue removed is synovial membrane showing an increase in fibrous tissue; it is composed of proliferating fibroblastic structures and many blood vessels. These

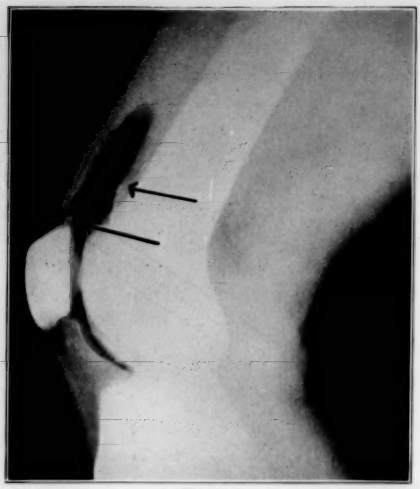

FIG. 14

FIG. 15

Fig. 14: Showing a calcified plica. Arrows indicate small nodules between which oval communication extends.

Fig. 15: Organizing hemarthrosis of ten days' duration.

are apparently just beneath the synovial membrane proper. Another section shows dense hyalin fibrous tissue with foci of inflammatory cells."

The diagnosis was chronic synovitis with hyalinized synechia. We now know that the "synechia" represented a thickened plica.

A follow-up after nine years showed the knee to have good motion and fair power. There had been no recurrence of the symptoms. The man, at the age of fifty-two, is doing telephone installations.

As to the mechanism of internal derangement of the knee due to an abnormal plica, several possibilities exist:

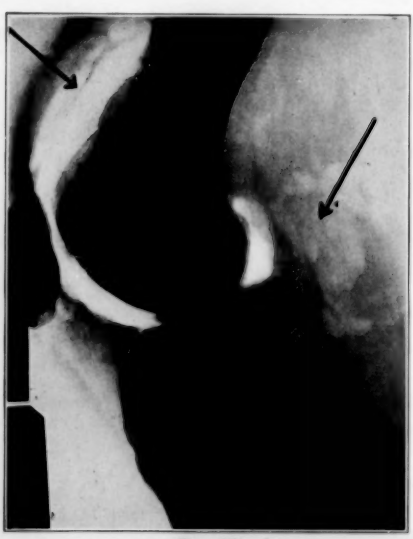

FIG. 16

FIG. 17

Fig. 16: Rheumatoid arthritis with distended bursae.

Fig. 17: Lateral roentgenogram taken after injection of lipiodol mixed with olive oil. (Reproduced, by permission, from *American Journal of Roentgenology*, 32: 791, 1932.)

1. An improperly treated hemorrhage (Fig. 15) or other abnormality may produce a hyalinized or calcified band about the middle of the suprapatellar pouch (Cases 1 and 2), limiting its adaptability as the thigh changes shape in various positions, so that synovial pinches result.

2. Moore suggests that the bandlike constriction interferes with the action of the articularis genu, the function of which is to retract the capsule during extension of the knee, thereby preventing it from getting nipped.

3. Similarities between Baker's cyst and suprapatellar bursa may be found. Wilson and his associates postulated a differential hydraulic pressure between the knee and the gastrocnemius-semimembranosus bursa with valve-like action in the development of a Baker's cyst. A case of rheumatoid arthritis with distension of the gastrocnemius-semimembranosus bursa and the suprapatellar bursa is illustrated (Fig. 16). The knee joint is relatively free and has served as a pump to displace the wastes of the rheumatoid process into bursal reservoirs. Figure 17 presents similar evidence, taken from the article by Burman and his associates, and shows a knee several weeks after injection with lipiodol. The pump action of the knee has displaced most of the dye into the suprapatellar bursa. The communication between the synovial membrane and the bursa is sufficiently valve-like to keep it there. It is logical that a differential hydraulic pressure, due to a valve-like action of communication between the bursa and knee joint, is a factor in the chronicity of some of these conditions, and explains why they are temporarily relieved by rest.

CONCLUSIONS

1. In 78 per cent. of adult knees, a suprapatellar synovial plica exists, representing the fusion of the suprapatellar bursa with the knee joint.

2. In pneumo-arthrograms the density of the suprapatellar plica serves as an index of synovial reaction, and is of value in prognosis.

3. Fibrosis, hyalinization, or calcification of the suprapatellar plica mechanically interferes with the extensor apparatus, producing a syndrome of pseudo "locking", pain, and chronic effusion, which is to be differentiated from other intra-articular disabilities.

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THE CAPSULAR MECHANISM IN RECURRENT DISLOCATION OF THE SHOULDER

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A survey of the literature of the last two decades suggests that it might be superfluous to add to the much discussed and variously treated condition of recurrent dislocation of the shoulder joint. However, certain recent articles on the subject indicate that misconceptions still exist as to the nature of the basic pathological condition and the interpretation of its significance.

This study is based upon observations of surgical cases, anatomical dissections, and the function of the various structures of the shoulder in preventing anterior dislocation. An attempt has been made to learn the end results in fifty-eight cases of anterior recurrent dislocation of the shoulder. All but two of the injuries in these cases were service-connected, so that follow-up examination was difficult.

Of the fifty-eight patients, sixteen had had repair by the Nicola technique, and forty by a slight modification of the Bankart method. One patient was treated by shortening of the capsule at its medial attachment, and one by a modification of the Magnuson procedure. Adequate clinical follow-up studies were possible on eight cases treated by the Nicola method, twenty-five treated by the Bankart method, and the one case in which capsular shortening was done.

Information as to the pathological condition found at surgery was available in twenty-seven cases. In twenty-two (81 per cent.), the capsule was separated at the glenoid attachment. In all but two there was some degree of injury or separation of the glenoidal labrum. In none was a definite tear in the body of the capsule demonstrated.

MECHANICS OF DISLOCATION

In the injury leading to acute anterior dislocation of the shoulder, abnormal stress is placed on the buffering mechanism of the anterior portion of the capsule and its glenohumeral ligament. The dislocation may be caused by a direct blow to the shoulder, by force transmitted from the hand or the elbow, or by overpowering external rotation or hyperextension. The injury usually occurs with the shoulder in external rotation, because in this position the capsule is taut, with the humeral head abutting against it, and there is less leeway for further displacement of the humeral head unless disruption of the capsule occurs (Figs. 1-A and 1-B).

The initial injury in recurrent dislocation of the shoulder appears to be the same as in those dislocations which do not become recurrent. Factors which tend to produce recurrent dislocation are: severe initial trauma and capsular separation; inadequate immobilization and, therefore, inadequate healing; persistence in excessive exertion; and repetition of the types of injuries which cause dislocation.

PATHOLOGICAL FINDINGS

The pathological factors involved in a dislocating shoulder, as described by Bost and Inman and by others, are generally understood and accepted. Detachment of the medial extent of the anterior portion of the capsule from the anterior aspect of the neck of the scapula or the glenoid rim, the separation or fracture of the glenoidal labrum, and the defect in the posterolateral aspect of the humeral head are the usual pathological findings. The avulsion of the medial attachment of the capsule is primary and is found in the great majority of cases. The fracture of the glenoidal labrum may be a part of the capsular

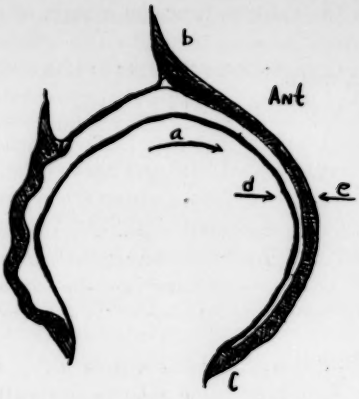

FIG. 1-A

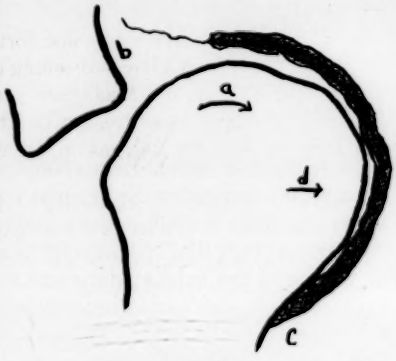

FIG. 1-B

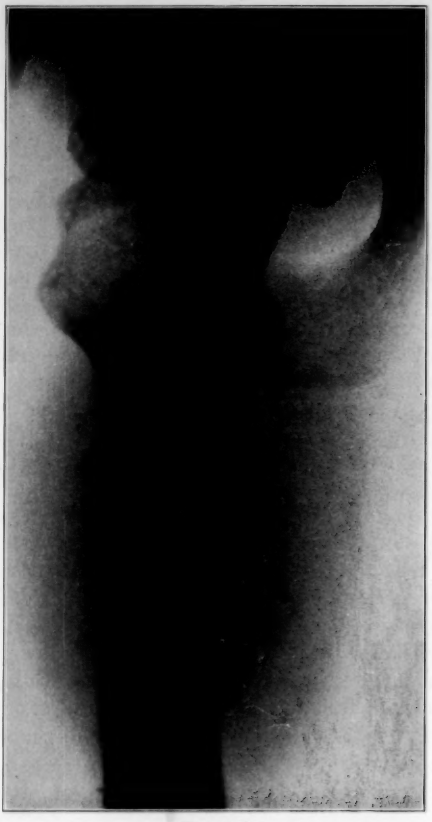

FIG. 2-A

Fig. 1-A: As the humeral head is forcefully turned in a position of external rotation (*a*), the distal portion of the capsule wraps around the head and becomes increasingly tense. Counteraction to the forward projecting force of the head (*d*) is provided by the increasingly resistant anterior capsule (*e*). Anterior dislocation can only occur if there is a disruption of this capsular mechanism by avulsion at the medial attachment to the glenoid margin (*b*), tearing in the substance of the capsule, or abnormal lengthening of the capsule.

Fig. 1-B: Avulsion has occurred at the medial attachment with resultant loss of the anterior buffering mechanism of the capsule, the anterior projecting humeral head becoming displaced forward over the glenoid margin. The wrapping effect of the capsule around the humeral head with tightening of the capsule is lost, due to lack of medial anchoring of the capsule.

Fig. 2-A: With the shoulder in internal rotation or neutral position, as shown here, the area of defect is well back in the glenoid fossa and the chance of dislocation is lessened.

separation or it may be secondary, as a result of trauma from the dislocating humeral head. It varies from a small defect to complete destruction of the labrum, depending upon the violence of the initial dislocation and upon the number and severity of redislocations which have occurred prior to operation.

Tears in the anterior portion of the capsule have been described by Odgers and Hark and by others. Those between and parallel to the glenohumeral ligaments should not produce recurrent dislocation. These tears can be produced by forceful external rotation of the dissected specimen, but anterior dislocation of the shoulder does not occur until the glenohumeral ligaments have been transected or the anterior portion of the capsule has been detached at the medial capsular attachment. Hark reported tears in the capsule at the level of the glenoid rim, leading to dislocation. When the anterior portion of the capsule is completely detached from the rim, there may be retraction of the capsule distally to

such an extent that the tear may appear to be in the capsule, near the margin of the glenoid.

DEFECT IN HUMERAL HEAD

The defect in the head of the humerus is secondary, and occurs because the anterior capsule, being disrupted and functionally lengthened, approaches and finally overrides the anterior glenoid margin as the shoulder is externally rotated. Hill and Sachs believed that this mechanism can be the result of a single violent dislocation, causing a severe impact of the posterolateral aspect of the humeral head against the anterior glenoid margin. However, the cause of the defect is relatively unimportant, since it cannot occur unless there is first a functional lengthening of the capsule.

In the normal shoulder, or after re-establishment of the anchoring function of the anterior capsule by surgical intervention, this area of defect cannot approach and impinge on the anterior glenoid rim. Its only role is in allowing dislocation to occur earlier in the motion of external rotation or abduction.

A roentgenogram in the axillary or vertical projection, with the arm in approximately 30 degrees of external rotation, shows the proximity of the area of defect to the anterior glenoid margin when functional lengthening of the anterior portion of the capsule is present (Figs. 2-B and 2-C). This position of external rotation was slightly less than that necessary to produce dislocation. Slightly more external rotation caused the shoulder to become redislocated three times before this view was obtained. At operation, complete detachment of the anterior portion of the capsule from the scapular neck was demonstrated. There was eburnation of the glenoid rim, and the glenoidal labrum was detached and traumatized beyond recognition. Repair was accomplished by reattaching the capsule to its anatomical position at the glenoid margin without shortening the capsule appreciably. No attempt was made to replace the glenoidal labrum. Nothing further was done to replace the so-called buffering function of the glenoidal labrum or to obliterate the part that the humeral-head defect might have in producing a redislocaton. The tendon of the subscapularis was not shortened.

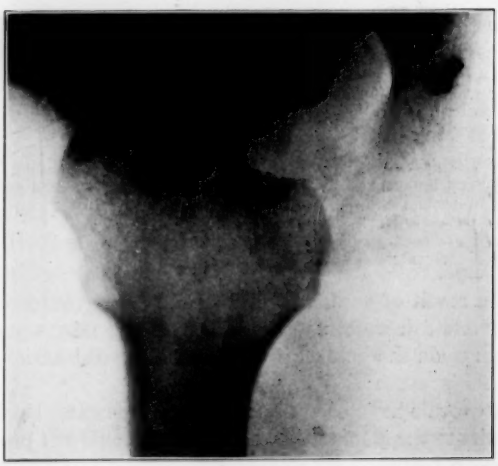

FIG. 2-B

FIG. 2-C

Fig. 2-B: Preoperative axillary roentgenogram shows disruption of the medial attachment of the anterior capsule, allowing the humeral head and the area of defect to approach the anterior glenoid margin. External rotation to any degree greater than present here (30 degrees) caused this shoulder to become dislocated prior to operation.

Fig. 2-C: Shows an accurate tracing of the roentgenogram, to demonstrate loss of the capsular mechanism. Anterior aspect is at the left.

Roentgenograms taken eight weeks and six months after operation, with the arm held forcefully at its limit of external rotation at approximately 45 degrees and 70 degrees, respectively (Figs. 2-D to 2-G), show that the humeral head and the area of defect occupied a more posterior position as related to the anterior glenoid rim. The defect does not approach the anterior margin of the glenoid fossa, even though a much greater degree of external rotation existed than had been necessary to cause dislocation before operation.

FIG. 2-D

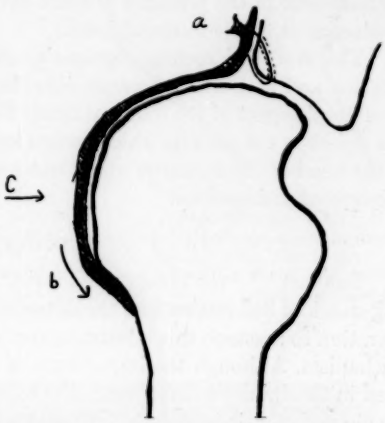

FIG. 2-E

Same case as in Fig. 2-A. Eight weeks after operation the patient's ability to externally rotate had increased to 45 degrees; the shoulder could be held forcefully in this position while the roentgenogram was taken. The anterior capsular mechanism has now been re-established and is exerting a backward pressing force on the humeral head, pushing it posteriorly in the glenoid fossa in spite of increased external rotation. Note that the coracoid process has become reattached anteriorly.

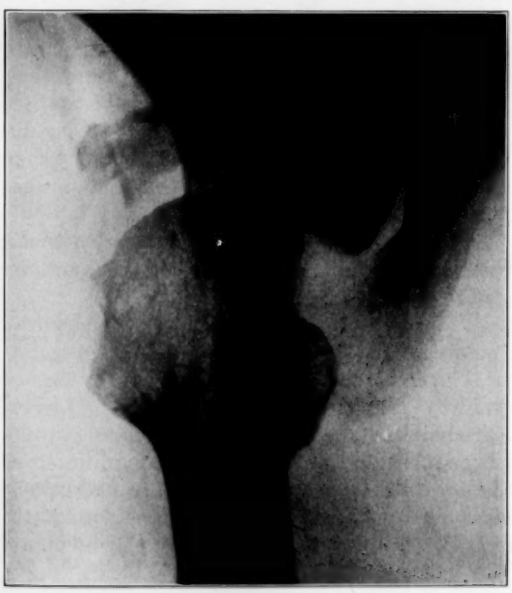

FIG. 2-F

FIG. 2-G

Seven months after operation, showing external rotation at 80 degrees. The area of defect still has adequate displacement posteriorly from the anterior margin.

It can be further demonstrated roentgenographically that, in normal shoulders, even though both external rotation and anterior displacement are forced to the limit, the area of the humeral head on which the defect is usually found does not approach the anterior glenoid margin and, therefore, could not cause dislocation unless the capsule had first been disrupted (Figs. 1-A and 3-D).

The minimal effect of these posterolateral defects in producing recurrent dislocation has been emphasized by defects produced on the cadaver. Unless the anterior portion of the capsule is transected or detached at the anterior glenoid margin, anterior dislocation cannot occur in the presence of these defects with forceful external rotation and anterior displacement of the humeral head.

The study of roentgenograms of 200 non-dislocating shoulders, taken in internal rotation and with axillary projections, has failed to reveal a congenital defect in the posterolateral aspect of the humeral head. These observations demonstrate that, unless there is a defect in the capsule which causes lengthening of the capsular mechanism, the defect in the head of the humerus would not seem to be a causative factor, either initially or in subsequent dislocations.

THE GLENOIDAL LABRUM

Bankart [1, 2, 3] for many years insisted that the only defect of importance in a recurring shoulder dislocation was the detached anterior glenoidal labrum. Bankart devised an operation to reattach this labrum to the capsule, and thereby restore its anterior buffering mechanism. Although the importance of the glenoidal labrum was probably overemphasized in the Bankart description, the medial portion of the capsule is also made secure to the glenoid margin by this procedure, thereby repairing the essential defect. This operation was highly successful, and continued emphasis was placed on the importance of the glenoidal labrum. However, it has become increasingly evident that the labrum has little, if any, role in the prevention of dislocation. In the presence of a normal capsule, the labrum adds to the smoothness of joint motion and, if the shoulder is in a relatively neutral position, probably adds something to the anterior barrier of the humeral head. However, after disruption of the anterior capsular mechanism, it affords only token resistance.

Traumatic cases, in which there have been relatively few dislocations, may show evidence of only mild or moderate injury to the labrum, even though the capsule has been detached from the medial margin. On the other hand, with non-traumatic recurring dislocations on a primary neuromuscular or congenital basis, the glenoidal labrum may show severe trauma at operation, yet have an intact capsular attachment. Furthermore, when there is a separation of the glenoidal labrum, dislocations do not recur.

In external rotation of the shoulder—the position in which anterior dislocation is most likely to occur—there is no forward displacement of the humeral head against the anterior glenoid lip, if the anterior portion of the capsule is intact.

Roentgenograms of a normal shoulder (Fig. 3-A) show an abuttment of the humeral head against the anterior lip with the shoulder in extreme internal rotation, demonstrating the normal width of the joint space at this level. When the shoulder is externally rotated and the humeral head is displaced forward by pressure on the humerus, it would be expected that the humeral head would be firmly in contact with the anterior glenoid lip and the glenoidal labrum, if the latter is to play a role in the prevention of anterior dislocation. However, in this position the interval between the humeral head and the anterior lip is much wider than the normal joint width (Fig. 3-D). Therefore, when the shoulder is in the most favorable position for dislocation, the anterior glenoidal labrum is playing no part in buffering the anterior displacement of the humeral head.

On the dissected specimen, the anterior glenoidal labrum can be removed by a posterior approach, the anterior capsular mechanism being left intact; and it is again impossible to cause anterior dislocation, unless the anterior portion of the capsule and the

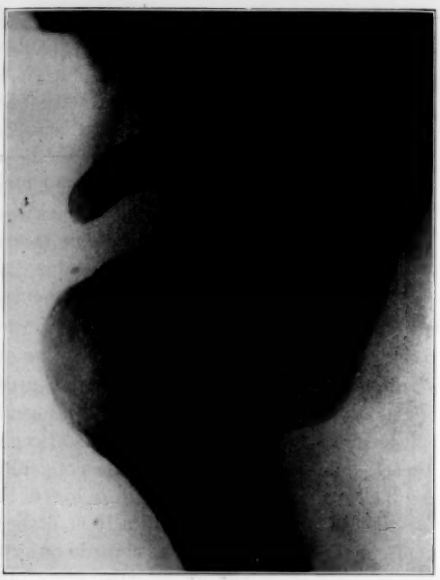

FIG. 3-A

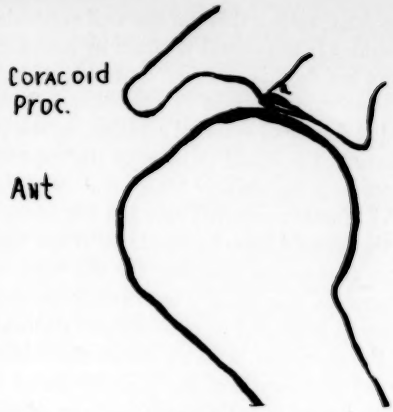

FIG. 3-B

Axillary view of a normal shoulder. With the shoulder in forced internal rotation, the humeral head is in direct contact with the anterior glenoid margin and glenoidal labrum, and the normal joint width at the anterior glenoid margin can be seen (Fig. 3-A). In external rotation there is an increased interval between the anterior glenoid margin and the humeral head, indicating that the anterior glenoidal labrum is offering no resistance to the humeral head (Fig. 3-D). Note the variation in posterior joint space, which becomes important in consideration of posterior dislocation.

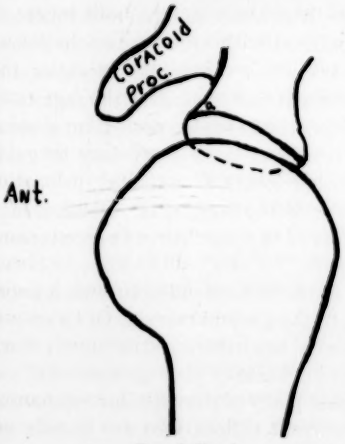

FIG. 3-C

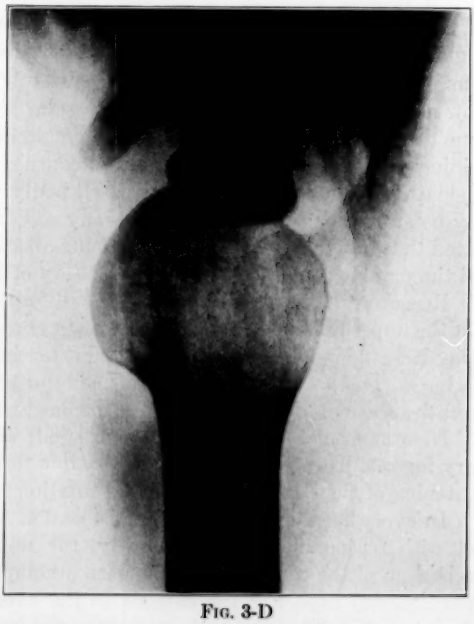

FIG. 3-D

glenohumeral ligaments are transected or detached from the glenoid margin. Thus it is difficult to determine how the anterior glenoidal labrum, or its absence, could exert any primary influence on the prevention or cause of recurrent dislocation.

THE CAPSULE

Failure of various capsular plications, popular at the beginning of the century, focused the search for a satisfactory repair on other more accessible structures of the

shoulder, rather than on the well concealed medial attachment of the capsule. When the shoulder is in neutral position or internal rotation, the anterior portion of the capsule is quite lax. In this position, however, there is little danger of anterior dislocation (Fig. 2-A). The anterior portion of the capsule becomes progressively more important with each added degree of external rotation, as the possibility of dislocation increases. With external rotation, the distal portion of the capsule becomes wrapped around the humeral head, becomes progressively tense, and exerts an increasing backward force on the head (Fig. 1-A). Further external rotation can occur only if the humeral head is displaced backward in the glenoid fossa by the force of the tight capsule, or if the capsule becomes lengthened by a tear or an avulsion. As the very motion which tends to produce the dislocation progresses, the usually lax capsule produces an increasingly effective barrier against the humeral head and ensures against dislocation. This capsular mechanism can be observed on the specimen, with all structures dissected away except the capsule. It can also be observed after repair of the capsular defect has been accomplished. Any condition or injury which brings about a permanent functional lengthening of the anterior portion of the capsule of sufficient degree will lead to recurrent anterior dislocation of the shoulder. Permanent lengthening of the anterior portion of the capsule may be caused by: a congenital defect or laxity of the joint capsule; neuromuscular disturbances which result in loss of the dynamic support of the shoulder, allowing the capsule to become chronically stretched; and residual effects of trauma, consisting of tears in the substance of the capsule or avulsion of the medial attachment of the anterior capsule from the anterior aspect of the glenoid margin.

Congenital dislocations, as discussed here, are due to an abnormal inherent functional lengthening of the shoulder capsule, and may be confused with true traumatic dislocations. A shoulder injury diagnosed preoperatively as traumatic recurrent dislocation may show neither disruption of the medial capsular attachment nor secondary damage to the glenoidal labrum. Congenital dislocation should be suspected in such a case, if no evidence of injury is seen in other portions of the capsule. A review of the history may reveal inadequate or vague trauma and increased laxity of other joints. Congenital dislocations may be anterior, posterior, or both. Many cases are probably congenital. Henderson reported that in five of twenty-seven patients, dislocation of the shoulder was spontaneous, and the patient could give no definite history of trauma.

Recently, in one such shoulder, the subscapular bursa was extended to such a degree that the upper half of the capsule had no attachment to the glenoid margin. Of twenty-six cadaver shoulders examined, two showed extensive loss of the superior attachment due to this bursa. This abnormal extension of the subscapular bursae may play an important part in the dislocations, due to inherent lengthening and inadequacy of the capsular mechanism.

Neuromuscular disturbances which result in recurrent dislocations are usually primary factors. These dislocations are also due to increased capsule length and loss of the tightening of the capsule with external rotation.

In every type of operation for dislocation of the shoulder, one common factor has met with reasonable success,—namely, the re-establishment of the anterior buffering mechanism of the capsule. This has been accomplished either by securing the torn or detached medial aspect of the capsule to the anterior glenoid rim, or by shortening the anterior portion of the capsule to such a degree that this structure becomes effectively tense during external rotation, by virtue of its remaining intact attachment to the anterior glenoid rim above and below the defect.

In Bankart's procedure the glenoidal labrum or the capsule is attached to the anterior glenoid margin by sutures through drill holes in the glenoid rim. The staple, reported by Maxwell [11, 12] as originally used by Perthes, and advocated at present by Ogilvie and Maxwell, secures the capsule to the glenoid margin without molesting or producing fibrosis of the anterior portion of the capsule. In the procedure of Gallie and LeMesurier,

which was originally designed to reconstruct the anterior portion of the capsule, the capsule is reattached to the glenoid margin by virtue of the fascia passing first through the scapular neck and then through the capsule itself. In the bone block, devised to produce an anterior block to the humeral head, the capsule is also reattached, the bone first being passed through the capsule and then into the glenoid margin or scapular neck. In the Putti-Platt procedure [15], a short anterior capsule is fashioned from the distal portion of the subscapularis. The medial aspect of this is attached to the anterior glenoidal labrum or, if the labrum is not present, to the loose anterior tissue. In the latter instance, the repair is dependent upon the capsular attachments above and below.

In the Magnuson procedure, based on the hypothesis that recurrent dislocations are due to muscle imbalance, the anterior portion of the capsule is included in the laterally transplanted flap of the subscapularis tendon, and, with the tendon, the capsule is also shortened to a point where it limits external rotation by 50 per cent.[10] In the presence of complete detachment of the anterior portion of the capusle with bone erosion and somewhat inadequate antero-inferior and anterosuperior attachment, the latter two methods of repair would seem to permit recurrences unless external rotation is almost completely limited at the time of operation.

PREOPERATIVE EVALUATION

A careful history should be taken of the incidence and importance of the trauma, usually considered by the patient as the cause of the dislocation. This will aid in differentiating between congenital and traumatic dislocation. The direction of motion at the time of the dislocations should also be evaluated in relation to whether the dislocation is anterior or posterior. Anterior dislocations occur in external rotation, abduction, hyperextension, or a combination of these motions. Posterior dislocations occur with internal rotation, abduction, flexion, or a combination. In the examination, passive motion pursued to a point at which the patient may indicate a feeling of instability or of impending dislocation may, by analysis of the position at which these signs of preslipping or subluxation occur, give a fairly definite idea of the direction of the dislocation.

In addition to the usual anteroposterior views in internal rotation, vertical roentgenograms, projected from the axilla, should be taken with the shoulder in external and internal rotation. This visualizes the presence and size of defects of the glenoid rim or humeral head, and aids in differentiation between anterior and posterior dislocation.

OPERATIVE TECHNIQUE

The defect in dislocation of the shoulder is definite and permits definite repair. Restoration of the anterior portion of the capsule to as near an anatomical status as possible is the goal of the Bankart operation, rather than a "divided, reefed, double-breasted" capsule, to produce fibrosis, as advocated by Watson-Jones.

The approach used by the author is similar to that described by Bankart. The incision in the skin begins above and slightly medial to the coracoid process and, curving laterally and downward around it, continues downward in the interval between the deltoid and pectoralis major. The cephalic vein is retracted medially. If additional exposure is needed, the deltoid may be dissected from the clavicle for a short distance, and the superior portion of the pectoralis major tendon may be freed close to the humerus. The conjoined attachments of the pectoralis minor, coracobrachialis, and short head of the biceps are detached with the distal tip of the coracoid process and are gently retracted medially. After injury to the subscapularis tendon has been ruled out, this structure is dissected from the capsule, starting near the tendon insertion and leaving much of the thickness of the tendon on the capsule side. As the dissection is carried medially, the muscle element of the subscapularis is encountered. At this point the subscapularis separates readily, by blunt dissection, from the capsule and anterior portion of the glenoid process.

With external rotation, the humeral head readily becomes dislocated anteriorly and there is seemingly an abnormally lax capsule. To determine whether this laxity is congenital or is on a traumatic basis, the capsule is examined carefully for evidence of old trauma; if none is found, attention is focused on the medial attachment. The capsular detachment will usually not be detected until visualization from inside the joint is possible. By incising the capsule directly over the glenoid margin and parallel to it, the length is preserved in its entirety for use in subsequent repair. The medial attachment remaining on the anterior glenoid rim is then examined carefully. If there is separation of the capsule, a probe can be passed between the bone and the capsule. The joint is then explored for bone injury or joint mice.

If the capsule is completely detached, it is reattached to the bone of the anterior glenoid rim. If the detachment is incomplete, so that considerable tissue is retained over the anterior margin, the capsule may be sutured to this. If there is any question regarding the purchase of these sutures to the soft tissue on the anterior glenoid margin, direct reattachment to the bone should be done. The opposing surfaces of the capsule and the anterior glenoid margin should be freshened with a scalpel and osteotome.

If there is no separation of the medial attachment of the anterior portion of the capsule and no traumatic defects in the substance of the anterior portion, the basis for the dislocation is probably congenital. In this case the capsule should be shortened by bringing the retaining sutures through it farther distally, so that there is overlapping of the capsule at the medial aspect. Opposing surfaces should be freshened, but drill holes are not necessary.

Secondary trauma to the glenoidal labrum may be seen in a congenital dislocation of long standing, but should not influence the type of repair unless there is also separation of the capsule. There is variable attachment of the capsule to the glenoidal labrum, and in some cases considerable injury to the labrum may be seen without capsular separation from the bone. Any defects in the body of the capsule should be repaired.

Some attention should be directed to the amount of capsular shortening brought about by the repair. If a very large posterolateral defect of the humeral head is found on the preoperative roentgenograms, and there is danger of this approaching the anterior glenoid rim, even with restoration of normal capsule length, the capsule should be shortened moderately, external rotation of the shoulder being held at approximately 45 degrees at the time of repair. In true traumatic dislocations without excessively large defects of the humeral head, the capsule length should be restored to as near normal as possible, with the minimal amount of shortening consistent with a good repair. In congenital dislocations, the capsule should be shortened to a little less than its estimated normal length, with external rotation possible in the range of 45 to 60 degrees at the time of repair.

In dislocations on a congenital or neuromuscular basis, in which there is reasonable assurance of an intact but elongated capsule, a Magnuson operation, with the capsule included in the tendon flap, will produce the desired capsular shortening and will simplify the operative procedure. However, whenever the continuity of the medial capsular attachment is in doubt, exploration and repair should be done at the level of the glenoid lip.

The method of resecuring the detached medial capsular insertion to the anterior glenoid margin is a matter of personal preference. Heavy braided silk or heavy chromic catgut, passed through drill holes fashioned in the glenoid margin, was used in the cases which formed the basis of this study.

Single or multiple bone pegs, which first have been passed through openings in the capsule and then driven into osteotomized openings or drill holes in the glenoid margin, can be used effectively. However, the primary aim is to reattach the capsule at the desired length, and any "blocking" effect obtained by the bone fragments should have secondary consideration. The bone pegs may eventually disappear, but first the capsule will have become securely attached to the glenoid margin.

The use of staples has been demonstrated by Ogilvie and Maxwell to be a very satisfactory method of reattachment to the capsule and to offer definite advantages. Similar to the staple is Dehne's method of using a screw and washer to secure the capsule. Gallie and LeMesurier's method of reattachment by use of the fascia lata in "reconstructing" the capsule has proved satisfactory, but the essential repair in this procedure is probably consummated as soon as the material is brought through the glenoid neck, then through the capsule, and is sutured to the latter structure. The capsule has not appeared to need reconstruction, and passing the material through the humerus and back to the coracoid process would seem to add labor and time out of proportion to the benefits derived.

It is unnecessary to use the distal portion of the subscapularis tendon as an anterior capsule, as in the Putti-Platt procedure, since in all cases this latter structure has been found to be normal and sufficient, except for the functional lengthening.

Postoperatively, the patient is placed in a modified Velpeau bandage or a secured sling and swathe, so that the shoulder is held in internal rotation for three weeks. At the end of this time, gentle flexion-extension exercises are allowed. At five weeks, physical therapy is started with motion in all directions. Sports and strenuous exertion are restricted for ten weeks.

EVALUATION OF RESULTS

A surgical technique or a series of cases should not be evaluated merely on the basis of the percentage of recurrences. Success or failure should also be based on the degree of function and activity which are possible without dislocation. For example, of the eight shoulders in the series which had been repaired by the Nicola procedure, four, or 50 per cent., had recurrence in less than two years. More significant than this poor percentage, however, is the fact that 100 per cent. of those patients who had performed more than light to moderate physical exertion had had recurrence. Without a statement of physical exertion, percentages may be misleading.

Of twenty-six shoulders repaired by a method aimed at restoration of the capsular mechanism, none had recurrence, regardless of the type of work or activity indulged in. Of nineteen patients with adequate follow-up six to twenty-four months after operation, seven were participating in activities involving extreme physical exertion, five were doing moderately heavy work, two were occasionally indulging in the type of activity which might lead to redislocation, and five were leading sedentary, fairly inactive lives. Evaluation of those nineteen cases on the combined basis of residual pain, range of motion in external rotation and abduction, muscle strength, and feeling of shoulder-joint security, with a point system of rating, showed that ten were excellent, seven were good, and two were fair.

SUMMARY

Functional lengthening of the capsule and loss of the anterior restraining effect of the capsular mechanism appear to be the primary causes of recurrent dislocation of the shoulder. Separation of the medial attachment of the capsule from the anterior glenoid margin is the most consistent cause of capsular lengthening. Congenital lengthening is probably present more often than is suspected, but interpretation is made difficult by the finding of secondary damage at the glenoid margin. The function of the normal capsule, which allows this usually lax structure to become an effective barrier against anterior projection of the humeral head in external rotation, is referred to as the *capsular mechanism*.

Repair should aim at re-establishment of the capsular mechanism. If there is no medial capsular separation, a modification of Magnuson's procedure is adequate. If there is separation of the capsule, but capsular tissue remains at the glenoid margin, sutures into the soft tissue only need be used. If there is complete loss of soft tissue from the anterior glenoid margin, the capsule should be anchored directly to the bone. Reattachment of the

glenoidal labrum is not necessary, and the presence or absence of this structure does not alter the operative procedure or the success of the repair. Limitation of shoulder motion to prevent dislocation is usually not necessary.

Bankart must be credited for focusing attention on the medial attachment of the capsule to the glenoid margin, and for gradual recognition of the correct operative procedure for the majority of cases of dislocation of the shoulder.

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PROGNOSIS IN IDIOPATHIC SCOLIOSIS

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The conservative attitude of this Clinic in the treatment of scoliosis has made it possible to accumulate a great number of cases of idiopathic scoliosis with prolonged follow-up studies, treated without surgery. These cases have been studied with the object of establishing criteria for determining the prognosis in idiopathic scoliosis.

Before an operation is undertaken in a young patient with scoliosis, the surgeon should have a thorough knowledge of the natural course of the curve he is going to treat and the probable outcome. The problem is so complex and so many abstract theoretical studies have been made that the orthopaedic surgeon is prone to overrate the dangers involved in scoliosis and to carry out surgical fusion of the spine which is often unnecessary. In many cases of idiopathic scoliosis, there is a natural tendency for the curve to stop progressing after a certain growth has been reached. Furthermore, the body posture is often well maintained in spite of sizable spinal curvatures. On the other hand, extremely deforming thoracic curves, requiring early and active treatment, may develop over a short period of time. It is the purpose of this paper to outline the course of the most common patterns of idiopathic curvature of the spine, and to give some basis for prognosis with any given curve.

Material

In a group of 444 young patients with idiopathic scoliosis, spine fusion had been performed in fifty cases. This study is based on an analysis of the 394 cases of idiopathic scoliosis which were not treated surgically. Of these, 335 cases were observed through maturity. Roentgenograms taken with the patient in the standing and supine positions, photographs, and clinical examination were employed in the study. Cases with minimal curves were not included. The average follow-up period was two years and ten months.

A great number of patients in this series received conservative treatment [3], consisting of exercises designed to increase muscle strength and to correct postural imbalance. Tightness of the abdominal muscles at the side of the overhang was corrected by passive and active stretching. The patients were taught to shift their thorax into proper alignment with the pelvis. Braces were often given to help maintain body posture. It is not our intention to evaluate the results of conservative treatment in this paper. While conservative therapy may improve body posture, it has never been found—or claimed—to decrease the size of a spinal curvature. As this study is based upon the characteristics of the curves, the fact that most patients received conservative treatment did not influence the results of our observations.

Measurement of Curves

The method used for determining the angle of a curve is as follows: The top and bottom vertebrae of the curve are identified by the width of the intervertebral space, the tilting, and the degree of rotation of the vertebrae. The intervertebral spaces are wider on the side of the convexity and narrower on the concave side. At the top and bottom of the curve, the intervertebral space is either of equal width or is wider toward the concavity of the curve. The rotation of a vertebra is indicated on the roentgenograms by the relationship of the spinous process to the body of the vertebra. The degree of rotation is greatest at the apex of the curve and diminishes toward each end, where a neutral vertebra—that is, a non-rotated vertebra—is frequently found. The top and bottom vertebrae

are usually the ones which rotate the least in the curve, but an exception should be made for the cases with curves showing concave rotation. Lines are drawn parallel to the upper surface of the top vertebra and to the undersurface of the bottom vertebra. The angle formed by these lines is the angle of the curve.

Curve Patterns

In idiopathic scoliosis, most of the characteristics of the curve or curves are present from the onset of the deformity and do not change throughout its entire course. The size of the curvature may increase considerably, and in some cases one or two more vertebrae may be included in the curve in the late stages. However, the apex, the direction of rotation, and the location of the curve do not change. Roentgenograms taken shortly after the onset, when the curvature is still minimal, point almost unmistakably to the pattern of the scoliosis (Figs. 4-A to 4-C and 7-A to 7-D). Only in exceptional cases does a change in pattern occur during the development of the scoliosis.

It was possible to group all the cases of idiopathic scoliosis studied into five main patterns: main lumbar, main thoracolumbar, combined thoracic and lumbar, main thoracic, and main cervicothoracic. In Table I the 394 cases are classified according to the curve patterns. These groupings correspond quite closely to the ones described by Schulthess in 1905.

The course and prognosis in idiopathic scoliosis vary considerably from pattern to pattern. For this reason, each group will be considered in detail.

Age at Onset

The final angular value of a curve is usually correlated with the age at which the scoliosis begins. However, it is often difficult to determine just when the curvature starts. In children who are well cared for, the scoliosis may be detected shortly after its onset;

TABLE I

SUMMARY O. 394 CASES OF IDIOPATHIC SCOLIOSIS TREATED WITHOUT SURGERY

Curve Pattern	No. of Cases	Sex		Average Age						Convexity to		Average Degrees			
				When Curve First Noticed		At First Visit		At Stabilization				At First Visit		At Stabilization	
		M.	F.	Yrs.	Mo.	Yrs.	Mo.	Yrs.	Mo.	Rt.	Lt.	St.	Sup.	St.	Sup.
Lumbar	93 (23.6%)	13	80	13	4	14	1	14	10	28	65	33.9	27.7	36.8	29.1
Thoracolumbar	63 (15.9%)	14	49	13	11	14		15	11	51	12	36.3	31.6	42.7	35.0
Combined Thoracic	146 (37.1%)	11	135	12	4	13	1	15	5	136	10	44.0	39.8	51.9	41.4
Combined Lumbar										10	136	35.1	30.1	41.4	37.7
Thoracic	87 (22.1%)	25	62	11	1	12	10	16	1	79	8	60.2	53.7	81.4	73.8
Cervicothoracic	5 (1.3%)	1	4	15	2	16		16		1	4	32.6	30.0	34.6	32.2
Totals	394 (100%)	64	330							295	99				

Rt. = right. Lt. = left.
St. = standing. Sup. = supine.

TABLE II

COURSE OF IDIOPATHIC SCOLIOSIS IN 335 CASES, CORRELATED WITH PATTERN AND AGE OF PATIENT AT ONSET OF CURVE

Curve Pattern	Age of Patient When Curve First Noted (*Years*)	No. of Patients	Angle of Curve at Maturity No. of Patients with Curves Measuring (Degrees): Under 40	40 to 60	60 to 80	Over 80
Main Lumbar						
Apex: 1st or 2nd lumbar	Under 10	9	4	4	0	1
Extent of curve: 11th thoracic to 3rd lumbar	From 10 to 12	12	6	4	1	1
	From 12 to 14	34	22	10	2	0
	Over 14	33	20	11	2	0
Total		88	52 (59%)	29 (33%)	5 (6%)	2 (2%)
Thoracolumbar						
Apex: 11th or 12th thoracic	Under 10	3	1	0	0	2
Extent of curve: 6th or 7th thoracic to 1st or 2nd lumbar	From 10 to 12	3	1	0	1	1
	From 12 to 14	22	7	8	7	0
	Over 14	26	18	4	4	0
Total		54	27 (50%)	12 (22%)	12 (22%)	3 (6%)
Combined						
Thoracic	Under 10	14	T. 0	3	4	7
Apex: 7th or 8th thoracic			L. 1	4	3	6
Extent of curve: 6th to 10th thoracic	From 10 to 12	28	T. 3	10	14	1
			L. 10	16	2	0
Lumbar	From 12 to 14	45	T. 12	23	6	4
Apex: 2nd lumbar			L. 21	18	6	0
Extent: 11th thoracic to 4th lumbar	Over 14	30	T. 13	17	0	0
			L. 26	4	0	0
Total		117	T. 28 (24%)	53 (45%)	24 (21%)	12 (10%)
			L. 58 (50%)	42 (36%)	11 (9%)	6 (5%)
Main Thoracic						
Apex: 8th or 9th thoracic	Under 10	18	0	1	4	13
Extent of curve: 5th or 6th thoracic to 11th or 12th thoracic	From 10 to 12	16	0	1	4	11
	From 12 to 14	21	1	8	5	7
	Over 14	16	4	3	5	4
Total		71	5 (7%)	13 (18%)	18 (25%)	35 (50%)
Cervicothoracic						
Apex: 3rd thoracic	Under 10	0	0	0	0	0
Extent of curve: 7th cervical or 1st thoracic to 4th or 5th thoracic	From 10 to 12	0	0	0	0	0
	From 12 to 14	1	0	1	0	0
	Over 14	4	3	1	0	0
Total		5	3	2	0	0

T. = Thoracic. L. = Lumbar.

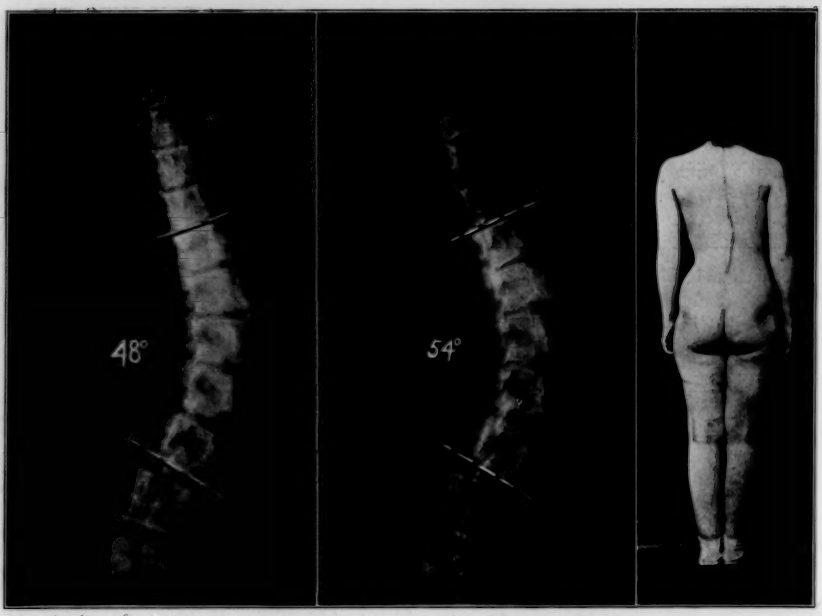

FIG. 1-A FIG. 1-B FIG. 1-C

Fig. 1-A: Roentgenogram* showing lumbar curve in a thirteen-year-old girl. Scoliosis had first been noticed at the age of twelve. Apex is at first lumbar vertebra. Curve extends from eleventh thoracic to third lumbar.

Fig. 1-B: At the age of seventeen years, there has been only minimal increase of the curve. Lumbar curves usually increase only slightly.

Fig. 1-C: Photograph of patient at seventeen years of age. Body posture was good.

in other children, the curve is often well advanced before it is noticed. The age of the patient at the time the curve was first noticed is used. In Table II, the cases observed until maturity were grouped according to the age of the patient when the scoliosis was first noticed. In each of the five patterns, four groups were made, according to whether the scoliosis was first noticed: (a) before the age of ten years; (b) between ten and twelve years; (c) between twelve and fourteen years; and (d) after fourteen years of age.

In each age group, the curves were classified according to their final angular values at maturity: (a) curves over 80 degrees at maturity (very severe); (b) curves between 60 and 80 degrees (severe); (c) curves between 40 and 60 degrees (moderate); and (d) curves under 40 degrees (small).

CURVE PATTERNS

Main Lumbar Curves

Single idiopathic lumbar curves occurred in ninety-three of the 394 cases studied (23.6 per cent.). They proved to be the most benign of all types of idiopathic curves. Eighty of the patients were females, thirteen were males. The average age at which the curvature was first noticed was thirteen years and four months. Lumbar curves became stabilized earlier than other patterns, at an average of fourteen years and ten months. Since vertebral growth in this group of cases was not complete until an average of sixteen years and eleven months, as evidenced by the completion of ossification excursion of the iliac apophyses[1], it may be assumed that it is not necessary for the growth of the spine to be terminated before the lumbar type of scoliosis is arrested.

* All the roentgenograms show the left side of the patient at the left side of the page. All were taken with patient in standing position and are anteroposterior views.

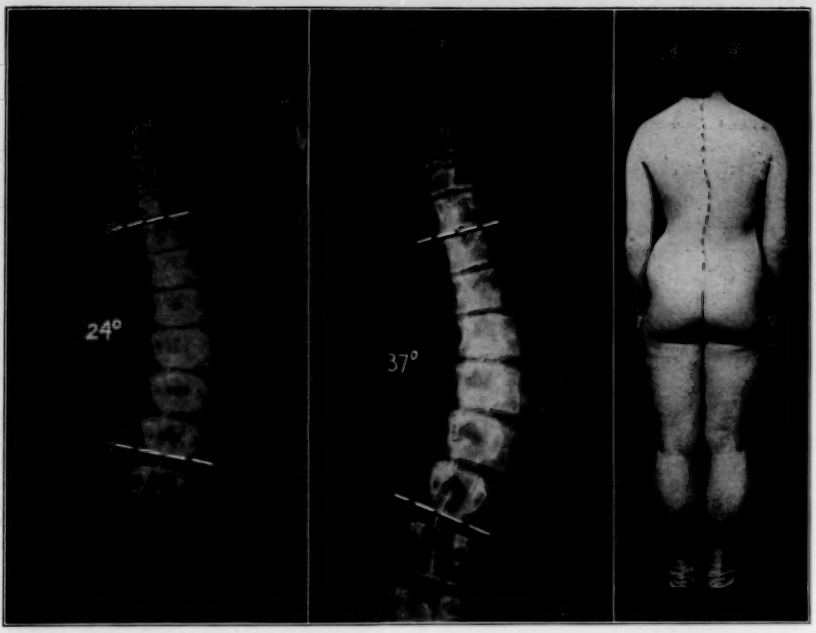

FIG. 2-A FIG. 2-B FIG. 2-C

Fig. 2-A: Thoracolumbar curve with apex at the twelfth thoracic vertebra in a ten-year-old girl. Scoliosis was first noticed at six years of age. Curve extends from the ninth thoracic to second lumbar vertebra.

Fig. 2-B: In spite of its early onset, curve had increased only slightly by the time the girl was seventeen years of age.

Fig. 2-C: Photograph of patient at seventeen years of age. Posture was good.

The lumbar curves generally included five vertebrae and extended from the eleventh thoracic to the third lumbar (Figs. 1-A, 1-B, and 1-C). The apex of the curve was at the first or second lumbar vertebra. They occurred predominantly to the left; sixty-five (70 per cent.) were convex to the left and twenty-eight (30 per cent.) were convex to the right.

Counter curves above and below the main lumbar curve were small, but constant. The two or three thoracic vertebrae above the curve were usually tilted opposite to the vertebrae in the lumbar curve, to form the upper counter curve and realign the body. These vertebrae often rotated in the same direction as the vertebrae in the lumbar curve. Thus, a *concave* rotation in the small thoracic counter curve was present.

The lower counter curve was formed by the fourth and fifth lumbar vertebrae. These two vertebrae were also tilted in the opposite direction to the lumbar curve, so that the undersurface of the fifth lumbar vertebra was horizontal and the sacrum was then neutral, or out of the curve. This was found in all but three of the ninety-three lumbar curves. In these three cases, the lumbar curve was lower, extending from the twelfth thoracic to the fifth lumbar, with the apex at the third lumbar vertebra. Here, the sacrum formed the counter curve.

Single lumbar curves were the least deforming of all the patterns. The gait, with the alternating rotation and oscillation of the pelvis, kept the lumbar spine limber, and extreme degrees of deformity were not seen. The average angular value after the curve had become stationary was 36.8 degrees with the patient standing, and 29.1 degrees supine. In only seven cases (8 per cent.) was the angular value of the curve over 60 degrees; but even in the more severe degrees of angulation, the curve was not very deforming.

Eighty-eight patients with lumbar scoliosis were observed until after they had reached

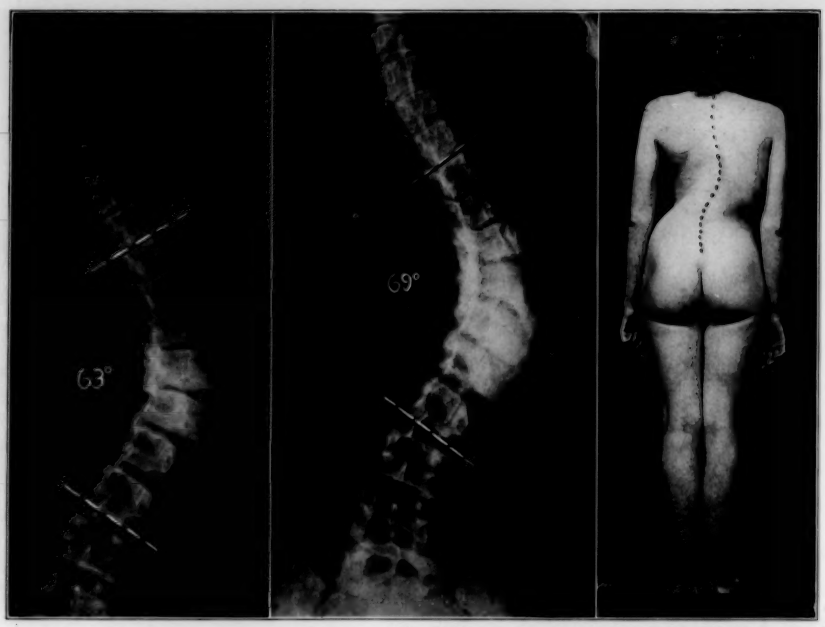

FIG. 3-A FIG. 3-B FIG. 3-C

Fig. 3-A: Thoracolumbar curve with apex at eleventh thoracic vertebra in a fourteen-year-old girl. Curvature was first noticed at eleven years. Extent of curve is from eighth thoracic to second lumbar vertebra.

Fig. 3-B: Roentgenogram of same patient at seventeen years of age. The course is typical for curves of this pattern.

Fig. 3-C: Photograph of patient at seventeen years of age. In spite of sizable curvature, the general body alignment is not greatly disturbed.

maturity (Table II). In nine cases (10.2 per cent.), the curve was first noticed before the age of ten. In spite of the early onset, in only one case did the curve increase beyond 60 degrees. In twelve cases, the scoliosis was first noticed between the ages of ten and twelve years; in two of these cases, the curve progressed beyond 60 degrees. Of the sixty-seven cases in which the scoliosis was first noticed after the age of twelve, only four had curves greater than 60 degrees, the highest value being 67 degrees. In no case, regardless of the age at which the curve was first noticed, was clinically severe deformity observed.

Minimal lumbar curves are quite common and were not included in these statistics. They are often not discovered until roentgenograms are taken to investigate the cause of low-back pain in adult life.

Thoracolumbar Curves

Thoracolumbar patterns occurred in sixty-three cases, or 16 per cent. of the total number of idiopathic curves studied. Of these, forty-nine were females, fourteen were males. The thoracolumbar curve had a great tendency to be convex toward the right, as did thoracic curves. Fifty-one or 80.9 per cent. were convex to the right, and twelve or 19.1 per cent. were convex to the left.

Six to eight vertebrae were included in the thoracolumbar curve, which extended from the sixth or seventh thoracic vertebra to the first or second lumbar. The apex was at the eleventh or twelfth thoracic; it was at the twelfth thoracic vertebra in forty cases and at the eleventh thoracic in twenty-three cases (Figs. 2-A to 3-C).

Although there proved to be no major differences in their eventual outcome, notable differences in the characteristics of these curves were found, depending upon the location

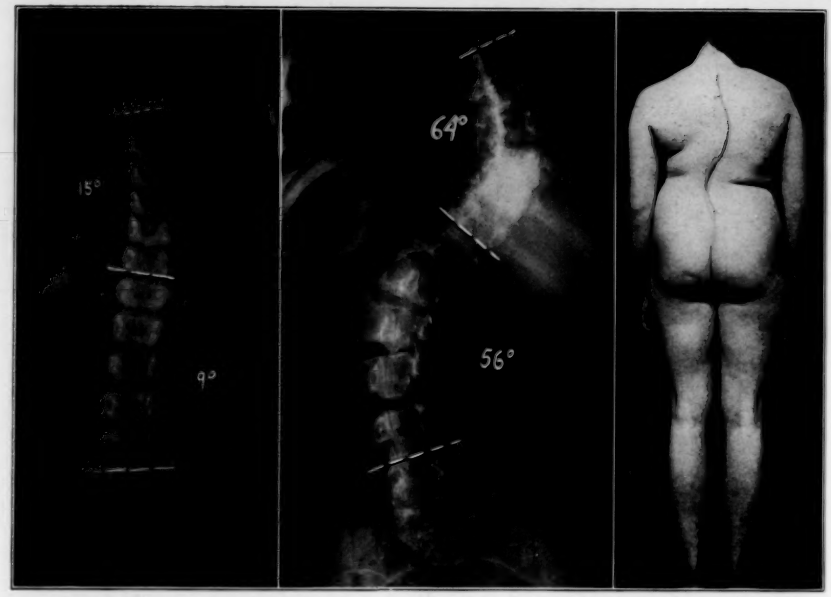

FIG. 4-A FIG. 4-B FIG. 4-C

Fig. 4-A: Combined thoracic and lumbar scoliosis in a nine-year-old girl. Roentgenogram was taken only a few weeks after curvature was first noticed, but pattern was already well defined.
Fig. 4-B: Roentgenogram of same patient at sixteen years of age, showing great increase of the curves. Increase of each curve was proportionate.
Fig. 4-C: Photograph of patient at sixteen years of age. In spite of size of the curvature, body remained well aligned.

of the apex. The curves with an apex at the eleventh thoracic vertebra had a tendency to grow larger and to penetrate into the thorax more than did the curves with an apex at the twelfth thoracic vertebra. When the apex was at the eleventh thoracic, the counter curves above and below the main curve were usually well developed and the vertebrae rotated toward the convexity of each curve (Figs. 3-A, 3-B, and 3-C). The sum of the angular values of the counter curves usually equaled the value of the main curve. The counter curves in the thoracolumbar scoliosis with an apex at the twelfth thoracic were very small or even non-existent. Usually the entire spine rotated toward the convexity of the main curve, and, if the counter curves existed, they showed a slight degree of concave rotation (Figs. 2-A, 2-B, and 2-C).

The thoracolumbar scoliosis started late. The average age at which the curve was first noticed was fourteen years. Fifty-four patients with thoracolumbar scoliosis were observed until they reached maturity. Spontaneous stabilization of the curve occurred at an average age of sixteen years, whereas the ossification excursion of the iliac apophysis of the patients in this group was not completed until an average age of seventeen years and four months. The average angular value after the curve had become stationary was 42.7 degrees with the patient standing, and 35.0 degrees when supine.

In six cases, the scoliosis was first noticed before the age of twelve years (Table II). In three cases of this group, the angle of the curve progressed beyond 80 degrees; in one case it was 67 degrees. The curve was small in the other two cases. In none of forty-eight cases in which the scoliosis was first noticed after the age of twelve years, did the curve reach 80 degrees; eleven had curves of from 60 to 80 degrees, and in twenty-five the curve did not increase beyond 40 degrees.

The thoracolumbar curves were, as a whole, not very deforming. The lower thoracic and the lumbar segments remained limber, and a good body posture was maintained in

all except eight cases. In only two of these was a major loss of body alignment observed. The scoliosis appeared at a very early age in both cases.

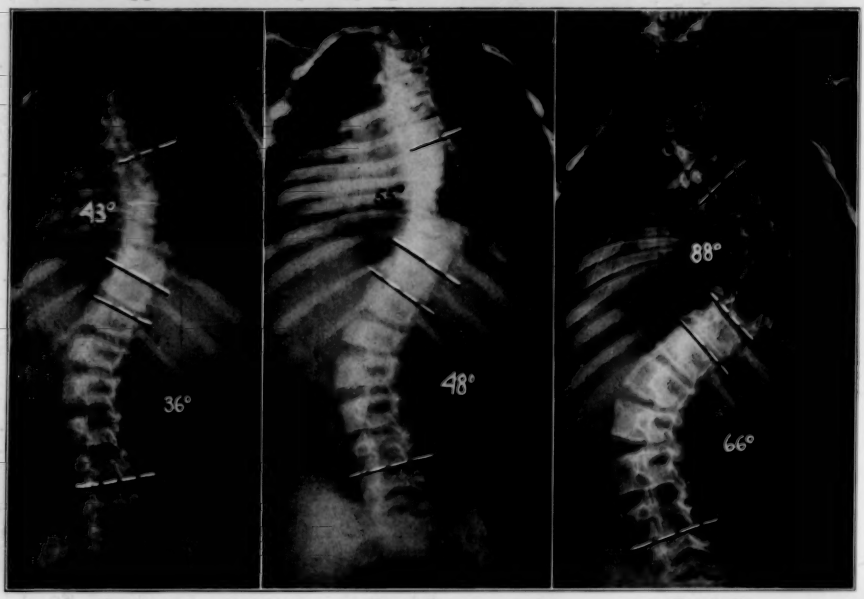

FIG. 5-A FIG. 5-B FIG. 5-C

Fig. 5-A: Combined thoracic and lumbar scoliosis in an eight-year-old girl. Curvature had been noticed for four months. Apex is at eighth thoracic vertebra in upper curve, and at second lumbar in lower curve.

Figs. 5-B and 5-C: Roentgenograms taken at nine and eleven years show gradual increase of both curves. The curves reached great size at maturity, as is seen frequently in the combined pattern when it starts at an early age.

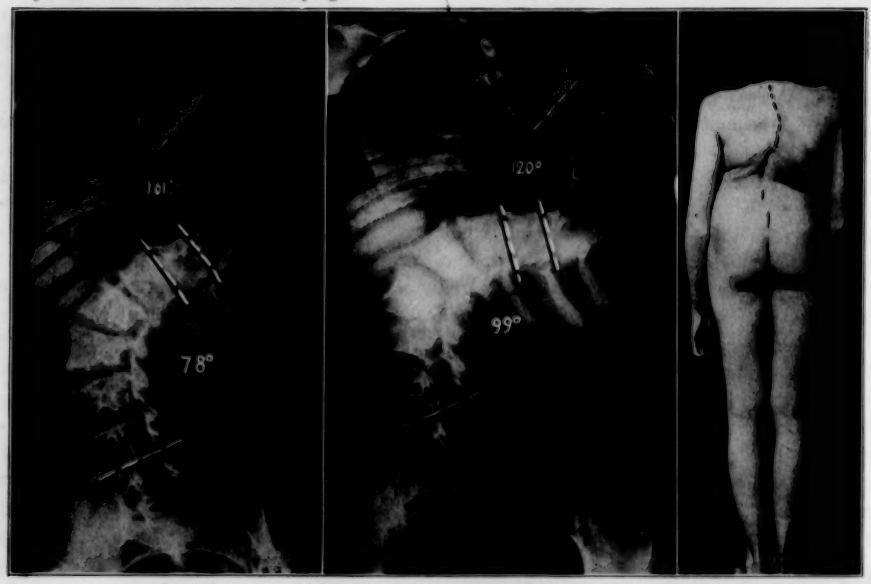

FIG. 5-D FIG. 5-E FIG. 5-F

Figs. 5-D and 5-E: Roentgenograms taken at twelve and fifteen years of age show further increase of the curves.

Fig. 5-F: Photograph of patient at fifteen years of age, showing deformity.

Combined Thoracic and Lumbar Curves

Combined scoliosis was the most frequent form in this series, with an incidence of 37 per cent. Of the 146 cases, 135 were girls and eleven were boys.

The cases of this group had two main recognizable curves from the very onset. One curve was thoracic, usually extended over a distance of five vertebrae from the sixth to the tenth thoracic vertebra, and had an apex at the seventh or eighth thoracic level. The other curve of opposite direction was lumbar, with an apex at the second lumbar, and included five vertebrae from the eleventh thoracic to the fourth lumbar. A few cases with six or seven vertebrae in each curve were seen. A neutral or non-rotated vertebra was often present between the two curves. The convexity of the thoracic curve was predominantly to the right and that of the lumbar curve was most commonly to the left. In the 146 cases, all but ten were right-thoracic, left-lumbar combinations (Figs. 4-A to 6-B).

FIG. 6-A FIG. 6-B

Fig. 6-A: Combined thoracic and lumbar scoliosis in a twelve-year-old girl. Scoliosis had been present for half a year.

Fig. 6-B: Same patient at seventeen years of age. Curves had increased very little. Curves of the combined pattern which start after eleven years of age usually do not increase greatly.

Usually both the thoracic and lumbar curves had the same number of vertebrae, and the rotation in each was toward the convexity of the respective curve. The degree of rotation of the vertebrae of one of the curves matched that of the other curve from the very beginning of the scoliosis. The thoracic curve usually measured several degrees more than the lumbar curve. The vertebral rotation and the angular value of both curves increased at about the same rate, so that the basic pattern changed very little. In this series, only rare instances were seen where one curve grew more than the other.

In forty cases (27 per cent.), the apex of the thoracic curve was lower than the seventh or eighth thoracic vertebra,—that is, at the ninth or tenth thoracic. The lumbar curve was, of necessity, short. When this scoliosis increased, an overhang of the body to the side of the convexity of the thoracic curve occurred and there was an upper cervicothoracic counter curve, opposite to the thoracic curve, which helped realign the body posture.

The average age of the patient when the scoliosis was first noticed was twelve years and four months. The average age at which the curve became stabilized was fifteen years and five months. The ossification excursion of the iliac apophysis in this group of cases was complete at an average of sixteen years and four months. One hundred and seventeen cases of the combined pattern were followed through maturity (Table II).

The prognosis in cases of combined scoliosis, in general, was good. The thoracic and lumbar curves were similar in length, rotation, and angular values. Consequently, the body was well aligned even when both curves reached considerable size. In many cases, curves of 60 or 70 degrees (Figs. 4-A, 4-B, and 4-C) were not detectable when the patient was dressed.

FIG. 7-A FIG. 7-B FIG. 7-C FIG. 7-D

Fig. 7-A: Main thoracic curve in a thirteen-year-old girl, shortly after onset.
Figs. 7-B and 7-C: Roentgenograms taken at fourteen and seventeen years. In spite of its late onset, curve increased greatly. Cases of this pattern usually follow a similar course.
Fig. 7-D: Photograph of patient at seventeen years of age, showing the deformity.

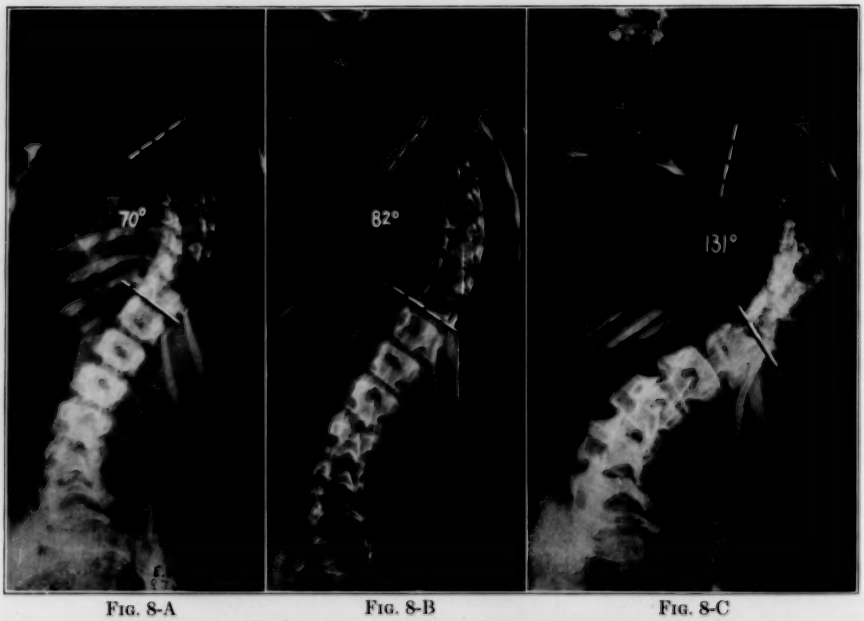

FIG. 8-A FIG. 8-B FIG. 8-C

Fig. 8-A: Main thoracic curve in a seven-year-old girl. Scoliosis was first noticed when patient was six. Apex was at eighth thoracic, and curve extended from fourth to eleventh thoracic vertebra.
Fig. 8-B: Same curve when patient was eleven years of age, showing some increase.
Fig. 8-C: Roentgenogram taken when patient was fifteen years of age shows great increase of the curve. The scoliosis progressed irregularly; it increased more rapidly during the period between eleven and fifteen years.

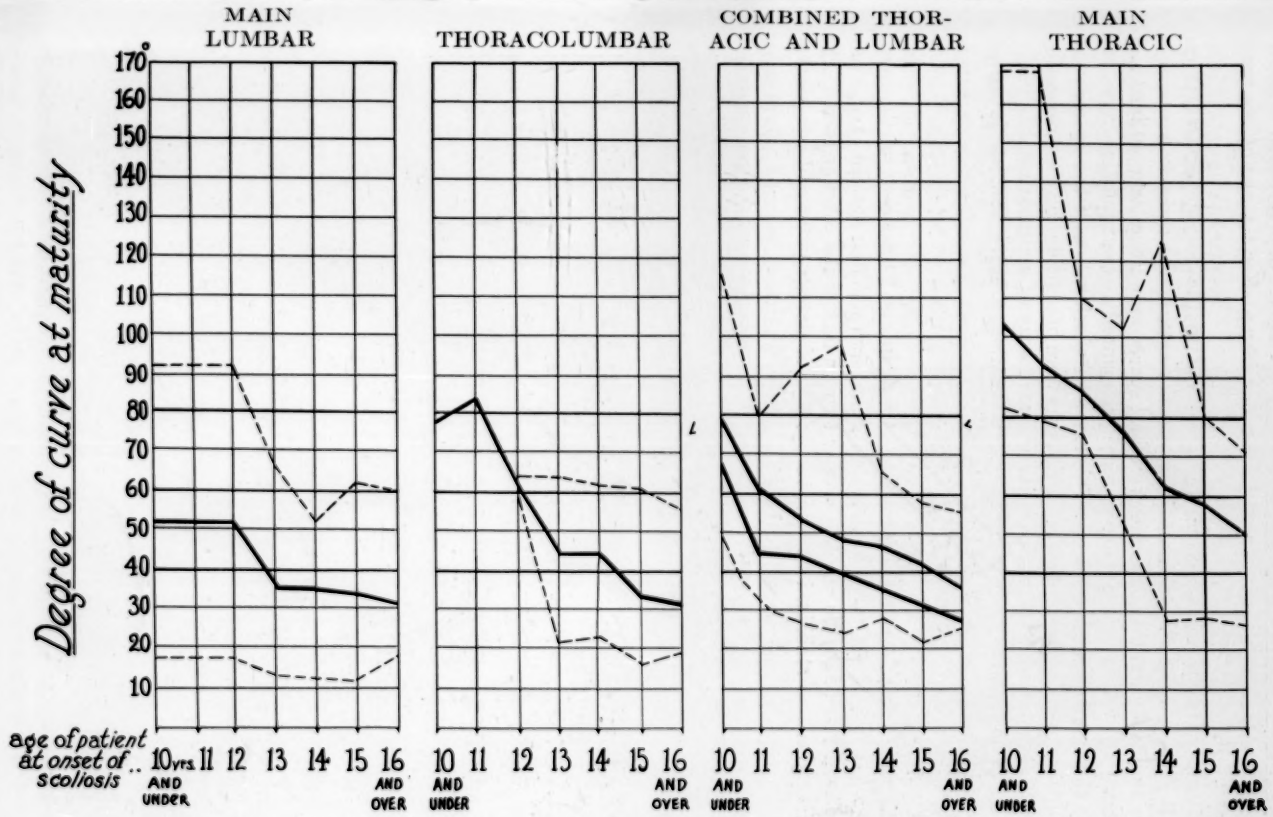

CHART I

Angle of curvature at maturity in each curve pattern, as related to the patient's age at onset of scoliosis. The solid lines represent the average angle; the broken lines, the extremes. In the graph of the combined thoracic and lumbar pattern, there are two solid lines. The upper one represents the thoracic component, the other represents the lumbar; only the extremes of the thoracic curve are shown. The small number of cases of cervicothoracic scoliosis were not included in the graph.

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The most important prognostic feature in this scoliosis pattern was the age of the patient when the scoliosis began (Table II). In seven of the fourteen cases in which the scoliosis was first noticed before the age of ten years, the curves increased to angular values of more than 80 degrees (Figs. 5-A to 5-F). This tendency of progression to extensive deformity dropped off sharply when the scoliosis began after the age of ten years (Figs. 6-A and 6-B).

Several important prognostic signs were observed in the roentgenograms (Figs. 9-A and 9-B). The thoracic vertebrae adjacent to the apex of the thoracic curve were osteoporotic and hazily outlined. The intervertebral spaces were irregularly outlined and narrow. A translatory shift was often seen, more pronounced at the transition vertebrae between the thoracic and lumbar curves. This is a sign of relaxation of the ligamentous apparatus of the spine. These roentgenographic signs were present during the progression of the curve; they were not seen in the scoliosis which remained stationary.

When all these features were taken into consideration, a fairly accurate prognosis of most of the combined curves could be made.

Thoracic Curves

Main thoracic curves accounted for eighty-seven cases or 22 per cent. of the total. Sixty-two were in females, twenty-five in males. This curve was first noticed at an average age of eleven years and one month,—earlier than in any of the other patterns. The thoracic curves became stabilized at an average age of sixteen years and one month,

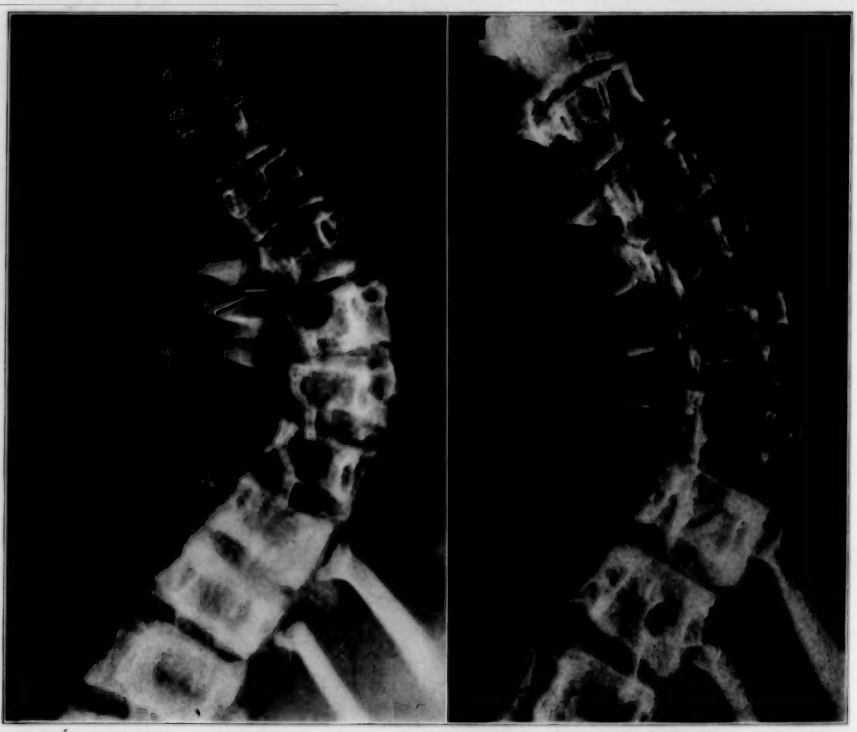

FIG. 9-A FIG. 9-B

Fig. 9-A: Roentgenogram showing lesions of the vertebrae in a main thoracic curve. Defects of the vertebral bodies on the concave side of the curve may be seen.

Fig. 9-B: Roentgenogram of the thoracic component of a combined thoracic and lumbar scoliosis. The vertebral bodies adjacent to the apex of the curve are osteoporotic, wedge-shaped, and poorly outlined.

thus allowing five years during which this curve increased. The ossification excursion of the iliac apophyses was complete at an average of seventeen years and one month.

Of the eighty-seven cases in this group, all but eight had curvatures convex to the right. Six of the eight patients with left convex thoracic scoliosis were boys.

The apex of the thoracic curve usually was at the eighth or ninth thoracic vertebra. Six vertebrae were generally included in the main curve, which extended from the sixth to the eleventh thoracic; extreme degrees of rotation were observed in the vertebrae. Smaller counter curves were present above and below the main curve. The rotation of the vertebrae in the counter curves was relatively mild (Figs. 7-A to 8-C).

FIG. 10-A

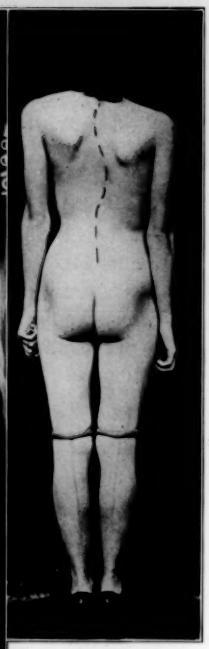

FIG. 10-B

Fig. 10-A: Composite roentgenogram showing a cervicothoracic scoliosis in a woman of twenty years. Curvature was first noticed when patient was fourteen and one-half years old. There is a long, low thoracic counter curve. Fig. 10-B: Photograph of patient, showing elevation of left shoulder.

The roentgenograms showed significant changes in the three or four vertebrae located in the center of the main thoracic curves (Figs. 9-A and 9-B). The bodies of these vertebrae appeared osteoporotic, their outlines were hazy, and early in the evolution of the curve they showed marked wedging. The intervertebral spaces were irregularly outlined and very narrow at the site of the concavity. Often disc herniations into the vertebral body were seen. Translatory shift between the vertebral bodies was often evident. These changes were seen before and during the progression of the curve. There was a direct relationship between the intensity of these lesions and the increase of the curve. These changes were much more pronounced than, but similar to, the ones seen in the thoracic component of the combined type of scoliosis.

Thoracic curves progressed more rapidly, grew to a greater size, and produced a greater deformity than any other type of scoliosis. The curve penetrated deeply into the thorax early in its course, producing an irreversible deformity.

When main thoracic curves started before the age of twelve years, the outlook was poor (Table II). Of thirty-four cases in which thoracic scoliosis was noticed prior to this age, in twenty-four or 70.6 per cent. the curve progressed to a final angular value greater than 80 degrees. In half of these cases, the deformity was extreme, with curves of angular values well over 100 degrees. The thoracic curve often had a tendency to progress to extensive deformity, even when it started late. About one-third of the patients whose scoliosis was detected after twelve years of age had curves measuring more than 80 degrees at maturity. However, in slightly less than half of the patients in this age group, the curves did not increase beyond 60 degrees and were not very deforming.

Cervicothoracic Curves

In the present series there were only five cases with this type of curve. The scoliosis was first noticed when the patient was about fifteen years of age, and never became pronounced. The angular value of the curve at maturity varied from 20 to 58 degrees. The curve was convex to the left in all the cases but one. Four of the patients were girls and one was a boy.

The apex of the cervicothoracic curves was at the third thoracic vertebra. From four to six vertebrae were included in the curve, which extended from the seventh cervical or first thoracic to the fourth or fifth thoracic. The curve penetrated somewhat into the upper thorax, and its vertebrae were wedge-shaped and markedly rotated. A long, low thoracic counter curve was usually present (Figs. 10-A and 10-B).

The scapula was elevated and the shoulder was higher at the side of the convexity of the curve. In spite of these visible deformities, the body alignment was well preserved in all the cases seen by us.

DISCUSSION

The study of the course of idiopathic scoliosis in a sizable number of cases has given valuable data upon which to base the prognosis. Four main factors were found significant.

1. The pattern of the curve;
2. Age of the patient at onset of the scoliosis;
3. Alterations in the density of the vertebrae and abnormalities of the disc spaces, as seen in the roentgenograms;
4. Rapidity of increase in the size of the curve.

Pattern of the Curve

The classification of idiopathic scoliosis into five main curve patterns was found to be fundamental in the determination of prognosis. These curve patterns were well established shortly after the onset of the scoliosis and, with a few exceptions, did not change throughout its course.

The pattern was easy to identify in the majority of cases. However, about 5 per cent. of the curves represented transition forms between two patterns, and had characteristics of each. Care was taken to classify these cases according to the pattern to which they bore closest resemblance. For example, nine cases had a main lumbar curve with a pronounced low-thoracic counter curve. These cases resembled the combined thoracolumbar patterns. However, they were classified with the lumbar curves for three reasons: First, the thoracic curve was a good deal smaller than the lumbar curve, whereas in the combined pattern, the lumbar curve is usually smaller. Second, the vertebrae of the thoracic curve were only slightly rotated, in contrast to the advanced degree of rotation usually noted in the thoracic curve of the combined pattern. Third, in the combined pattern there is a small, high thoracic or cervicothoracic counter curve, not present in these nine cases.

Transition forms were also seen between the lumbar and thoracolumbar patterns, the thoracolumbar and combined, and the combined and main thoracic. A careful study of each of these cases was necessary for their proper classification.

As a whole, the main thoracic curves increased to greater deformities than the other patterns. The prognosis in the main lumbar, thoracolumbar, and cervicothoracic curves was usually favorable. The prognosis with the combined thoracolumbar curves was usually good if they developed after ten years of age, and poor if they started earlier.

Age at Onset of the Scoliosis

The prognosis in cases of scoliosis depended in great measure upon the age of the patient when the curvature appeared. The most deforming curves originated at an early age. Conversely, the curves which were detected when the maturity of the patient was well advanced increased only slightly or not at all. The age of the patient when the scoliosis

became apparent varied within each pattern. The main thoracic curves usually appeared at an earlier age than the other curves. The curves in the lumbar, thoracolumbar, and the cervicothoracic patterns appeared late,—often after the age of thirteen years. It is possible that these curves may have been present for many months without becoming clinically apparent, because they were usually not very deforming.

It would be desirable to evaluate the skeletal age of the patients and to correlate it with the growth of the scoliosis. The idiopathic curves almost always increase during growth of the skeleton, and they cease to progress about one year before the completion of ossification excursion of the iliac apophyses. Unfortunately, we were not able to determine accurately the skeletal age of most of our patients, and thus the chronological age was used instead.

Idiopathic scoliosis is much more frequent in girls than in boys. In the group of cases with main thoracic curves, however, there were many males. The scoliosis often progressed in boys about two years longer than in girls. This was probably due to the fact that the skeleton reaches maturity later in males than in females. Otherwise, there were no major differences in the course of scoliosis in boys and girls, and the data were compiled together in the tables.

Alterations in the Density of the Vertebrae and Abnormalities of the Disc Spaces

Changes in the vertebrae and in the intervertebral spaces were often seen in the roentgenograms of the scoliotic patients. The vertebrae adjacent to the apex of the thoracic curves were most frequently affected (Figs. 9-A and 9-B).

Most of these changes were apparent in the thoracic curves when the first roentgenograms were taken, shortly after the onset of the scoliosis. They were seen during the entire progress of the curve. The intensity of these vertebral alterations was usually directly related to the rapidity of increase of the curve. Thus, these spinal changes were of major prognostic significance. The texture of the bone of the lumbar vertebrae appeared to be fairly normal, even in the most extensive lumbar curves. Translatory shift, however, was often seen between the lumbar vertebrae.

Rapidity of Increase in the Size of the Curve

When the scoliosis started after ten years of age, the increase was gradual in most of the patients. The prognosis, then, could often be best evaluated after two or three successive examinations, taken at intervals of three months. If the roentgenograms showed marked increase of the curve, the prognosis was usually poor. On the other hand, if there was only a minor progression of the curve during this period of observation, the prognosis was much better.

When the scoliosis started in children under ten years of age, it often did not increase much for a few years and then increased suddenly. This scoliosis of early onset usually carried a poor prognosis, in spite of its slow increase during the first years.

For practical usage, a graph was constructed for each curve pattern, to show the size of the curvature which might be expected at maturity, as related to the age of the patient at the onset of the scoliosis (Chart I). The central line represents the average angular value; the secondary lines, the extreme curves. Data for this chart were obtained from the study of the 330 cases of idiopathic scoliosis followed through maturity. Angular values of the curves in the standing position were recorded. The ages referred to in the graph are the chronological ages of girls.

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RADIATION SCOLIOSIS

An Experimental Study *†

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Experimental scoliosis has been produced in two ways,—indirectly by asymmetrical pressure on the vertebral bodies, and directly by destruction of epiphyses. The work of Schwartzmann and Miles and of Bisgard is representative of the indirect production of scoliosis, effected by applying asymmetrical tensions on each side of the growing spine. Asymmetry resulted from the excision or paralysis of the paraspinal muscles; the convexity was toward the affected side. Wullstein, by bandaging dogs in a position of curvature, used an asymmetrical pull outside the dog itself. In all of these cases, the asymmetrical extraspinal tension produced asymmetrical pressure upon the growing epiphyseal plates, resulting in asymmetrical growth and wedging of the involved vertebrae.

A direct effect on growth is illustrated by Haas and by Bisgard and Musselman, who destroyed the vertebral epiphyses surgically to produce structural scoliosis with wedging in growing experimental animals. Engel implanted radium needles alongside the spines of young goats, to suppress epiphyseal growth directly. As the goats grew, the irradiated vertebrae became wedged, with a decrease in height on the side of the vertebrae adjacent to the radium needle. Curvatures developed, with concavities on the irradiated side.

In an effort to develop other radiation techniques for the asymmetrical suppression of vertebral epiphyseal growth, studies have been made with interstitial radon seeds and external irradiation[1]. Interstitial radiation (radon or radium) has the advantages of sparing the skin and localizing the intense radiation. Permanent radon seeds are easy to implant, present a point source of radiation, and allow localization of the seeds by roentgenograms.

The use of external irradiation (roentgen-ray beam) has other advantages in suppressing vertebral epiphyseal growth. Fields of radiation may be varied easily, and surgical implantation is not necessary. Also, there are regions along the spine, particularly in the thorax, where it would be difficult to insert radium needles.

A radon seed in a strength of 0.6 millicurie, placed adjacent to an intervertebral space in the lumbar spine of a young rabbit (Fig. 1-A), resulted in suppression of the growth of the epiphysis on the side nearer the seed. A few months later, growth of the spine manifested its asymmetry by a wedging of the vertebrae adjacent to the source of radiation. This is illustrated in the roentgenograms of the excised spine, seven months after implantation of the seed (Fig. 1-C). The iliac crest and the transverse process of the last lumbar vertebra near the seed were stunted in growth (Fig. 1-B).

In order for asymmetry to occur, the seed must be placed near one side of the epiphyseal plate and must be of adequate strength. When radon seeds of 0.6 millicurie were placed opposite the middle of a vertebral body, or when 0.2 millicurie seeds were placed near one side of an epiphyseal plate, no discernible wedging was noted.

As indicated in Figure 1-D, growth suppression of the vertebral epiphyseal plate near the 0.6 millicurie seed was induced by a dose of about 2,700 gamma roentgens; the epiphysis next above the seed grew "normally", although it received a dose of 300 r. The 0.2 millicurie seed, which produced no discernible growth suppression, yielded a dose of

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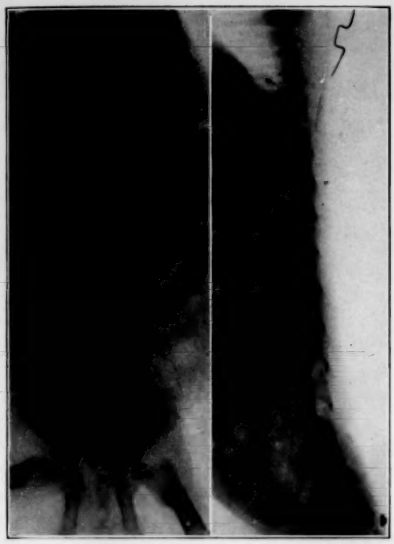

FIG. 1-A

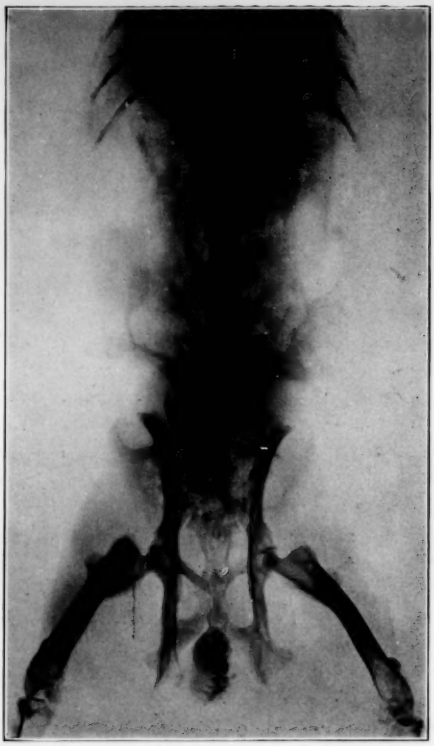

FIG. 1-B

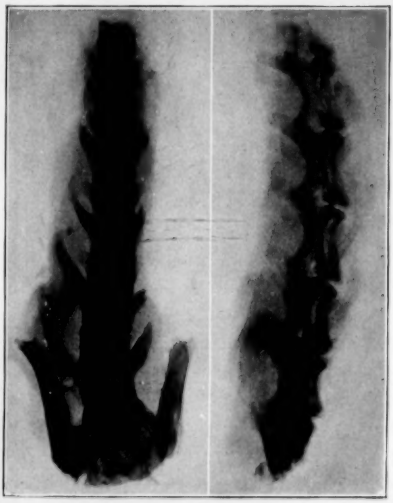

FIG. 1-C

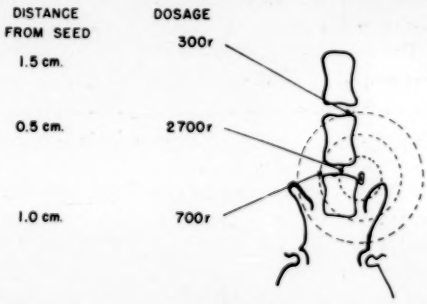

FIG. 1-D

Fig. 1-A: Rabbit No. 87. Roentgenograms made immediately after the implantation of an 0.6 millicurie radon seed, which lies adjacent to the upper epiphyseal plate of the last lumbar vertebra. At this time the rabbit was three weeks old.

Fig. 1-B: Rabbit No. 87. Roentgenogram taken six months after insertion of radon. The iliac crests and the transverse processes of the last lumbar vertebra were asymmetrical.

Fig. 1-C: Rabbit No. 87. Roentgenograms of excised spine show wedging adjacent to the radon seed. The animal was sacrificed seven months after insertion of the radon.

Fig. 1-D: Isodose curves around 0.6 millicurie seed, as implanted in Rabbit No. 87. Note the considerable difference between the dose in the involved epiphysis and in the epiphysis immediately above it (ratio of 9 to 1).

approximately 900 r to the epiphysis. Dosage determinations were based upon the work of Silverstone.

Similar asymmetrical growth arrest was effected by the use of a roentgen-ray beam. In this instance the radiation was directed toward one side of the lumbar vertebrae, through a

FIG. 2-A

FIG. 2-B

FIG. 2-C

Fig. 2-A: Rabbit No. 54. Seven weeks after external irradiation, wedging of the left side of the lumbar vertebrae was present, but there was no curvature.
Fig. 2-B: Rabbit No. 54. Twenty-four weeks after irradiation, wedging was more marked and curvature was apparent. The last rib and the upper lumbar transverse processes were dwarfed on the irradiated side.

Fig. 2-B: Rabbit No. 54. Twenty-four weeks after irradiation, wedging was more marked and curvature was apparent. The last rib and the upper lumbar transverse processes were dwarfed on the irradiated side.

FIG. 2-D

Fig. 2-C: Rabbit No. 54. Twenty-five weeks after irradiation, the animal was sacrificed. The curvature increased as soon as the spine had been excised.

Fig. 2-D: Rabbit No. 54. Histological coronal section (× 40) of wedged vertebra from the apex of the scoliotic curve shown in Fig. 2-C. The body of the vertebra has less height on the irradiated side, while the intervertebral discs are widened on the same side.

Fig. 2-E: High-power view of section of Fig. 2-D. Note abrupt cessation of line of epiphyseal columns at the middle of the figure.

FIG. 2-E

portal on the dorsum of the animal. The field measured 1 by 7 centimeters and the roentgen-ray factors were: 140 kilovolts, 20 milliamperes, a target-skin distance of 30 centimeters, filtration 0.25 millimeter of copper and 1 millimeter of aluminum, a half-value layer of 0.50 millimeter of copper, and a flux of 60 r per minute. The dose at the epiphysis was 1,000 r. Localization of the radiation beam was verified by taking roentgenograms with the therapy machine set for treatment.

FIG. 3

S-shaped curve produced by irradiation through a portal oblique to the long axis of the spine.

Seven weeks after exposure to roentgen rays, the involved lumbar vertebrae showed wedging (Fig. 2-A), with decrease in the height of the vertebrae on the irradiated side. Curvature of the spine was not present until more growth had occurred. Roentgenograms, twenty-four weeks after radiation (Fig. 2-B), showed the wedging to be more marked; a curvature with its concavity on the irradiated side was then present. Only after wedging became marked, was the curvature apparent.

Twenty-five weeks after radiation, the vertebral column was excised. Roentgenograms of the excised spine (Fig. 2-C) showed that the curvature was greater when the restraint of muscles and ligaments had been removed.

A microscopic section in the coronal plane of these wedged vertebrae (Fig. 2-D) showed that the irradiated side of the vertebra had decreased in height. Widening of the intervertebral disc on the irradiated side demonstrated the attempt of the animal to maintain a functionally straight spine while its vertebrae were wedged. This functional compensation became inadequate as wedging progressed, and spinal curvature then became manifest.

The irradiated half of all four epiphyseal plates illustrated in Figure 2-D shows a cessation of growth, as indicated by the absence of cartilaginous columns. The junction of non-irradiated and irradiated areas is shown in higher-power magnification (Fig. 2-E). The zone of temporary calcification is cellular and active on the control side; the irradiated side is irregular and relatively acellular, with growth prematurely arrested. For such a histological demonstration of arrest of growth in an epiphyseal line, the animal must be sacrificed at the optimal time, while the normal epiphyses are still growing and after the irradiated epiphyses have stopped growing. None of the animals showed gross or microscopic evidence of necrosis, marrow fibrosis, or inflammatory infiltration. The longest follow-up was fifteen months after radiation.

Localization of radiation from an external beam is demonstrated in the histological sections, but may also be shown by placing the beam obliquely on the spine. The resultant curvature reflects the obliquity of the field. The excised spine in Figure 3 has an S-shaped curvature. A dose of 1,000 r was given this rabbit through an oblique portal, by which the right side of the upper lumbar vertebrae and the left side of the lower lumbar vertebrae were irradiated. The rabbit was sacrificed thirty weeks after irradiation.

COMMENT

The scolioses illustrated in this paper are examples of the production of curvature by direct action of radiation upon the epiphyseal plate. The bone wedging is not the result of pressure from contractural scarring in the concavity of the curve (due to radiation), as the

intervertebral discs are wider, indicating *less* pressure on this side. In fact, the discs indicate that more pressure is falling on the higher sides of the bodies and, if the radiation arrest were temporary, the rabbits' efforts at functional correction might be expected to lead to improvement or eventual disappearance of the structural scoliosis.

By this method, direct unilateral suppression of epiphyseal growth can be controlled to produce wedging in a predictable area, an effect which may be applicable in clinical scoliosis.

CONCLUSIONS

Structural scoliosis can be produced in the spines of rabbits by irradiating the vertebrae asymmetrically.

The resulting unequal bone growth yields wedging of the vertebral bodies with the lesser height toward the irradiated side.

A single dose of 1,000 r is required to induce definite wedging in the spines of young rabbits.

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RADIATION-INDUCED SCOLIOSIS

A Case Report *†

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Retardation of long-bone growth following roentgen irradiation of the epiphyses is a well recognized effect, but few studies have been made on the results of retardation of vertebral epiphyseal growth by irradiation. The case report presented here demonstrates the development of scoliosis in a patient whose spine had been heavily irradiated in early childhood. No similar case has been reported in the available literature. Engel [1] induced scoliosis in young animals by placing radium needles on one side of the vertebral column. Retardation of growth caused wedging in the vertebral bodies adjacent to the

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radium needles, and the concavity of the scoliosis was toward the more heavily irradiated side. Curvature of the spine in young animals has also been induced by roentgen rays. Similar growth deformity seems to have occurred in the following case.

P. N., a thirteen-year-old schoolgirl, was seen in the Orthopaedic Service of the Monmouth Memorial Hospital, Monmouth, New Jersey, in November 1947. Her chief complaint was curvature of the spine, which had developed gradually and painlessly over a period of years.

In August 1935, at the age of six months, the patient was admitted to Memorial Hospital in New York City for excision of multiple benign (prepuberal) melanomata of the back. Her entire back was discolored by diffuse naevi on which were developing numerous discrete coal-black melanotic tumors. Although these lesions have all of the histological features of malignant melanomata except invasion by blood and lymph vessels, and were in fact diagnosed as melanomata by the late James Ewing, experience has shown that they rarely metastasize until after puberty. Because of this known later hazard, the pigmented tumors were excised

FIG. 1

FIG. 2

Fig. 1: September 1936. Intravenous urogram shows mass in left side of abdomen.
Fig. 2: Outline of anterior and posterior fields of irradiation.

during her infancy. By September 1936, when the child was nineteen months old, at least twenty-five of these neoplasms had been excised locally. Pathological study of the excised specimens showed them to be melanomata and naevi.

In September 1936, when the child was nineteen months old, a large mass was palpable in the left side of the abdomen. It extended from the costal margin to the level of the iliac crest inferiorly, and beyond the umbilicus medially. An intravenous urogram (Fig. 1) showed a mass of uniform density, occupying the left side of the abdomen and pushing the distorted calyces of the left kidney laterally. The bones included in the examination were normal. The spine was straight and the iliac bones were symmetrical.

The clinical diagnosis of Wilms tumor (embryonal adenomyosarcoma) was made, and the patient was treated by preoperative irradiation, nephrectomy, and postoperative irradiation.

The fields of roentgen treatment are indicated in Figure 2. The preoperative course of treatment was given from September 21 to October 19, 1936. Each of the three treatment fields (left anterior portion of abdomen, left posterior kidney, and left lateral kidney) received 1,100 r in air. The size of the fields varied from 13 by 10.3 to 15.6 by 7.8 centimeters. The target-skin distance was 50 centimeters, the kilovoltage was 198, and the filtration was 0.5 millimeter of copper.

On October 22, after one month of roentgen treatment, the tumor had diminished in size, and nephrectomy was performed. The mass was 9 by 7 by 5 centimeters in size when excised. "The kidney was largely replaced by a nodular tumor which involved both poles. The capsule was not perforated." The histological diagnosis was embryonal adenocarcinoma, grade III. It was not described as a typical Wilms tumor, since there were many embryonal tubules and abortive glomeruli. No radiation changes were seen in the specimen.

Postoperative roentgen treatments were started on January 26, 1937, and were completed on April 20. All radiation factors were the same as in the preoperative treatments, except that the fields were smaller, varying from 10.3 by 7.8 to 7.8 by 5.2 centimeters. Each of these fields received 2,100 r in air. The total dose to each field (preoperative and postoperative treatment) was 3,200 r in air.

FIG. 5

FIG. 4

Fig. 3: November 1947. Roentgenogram shows scoliosis of lumbar spine.

Fig. 4: November 1947. Note disparity in size of the ilia.

Fig. 5: Photograph taken in December 1948.

FIG. 3

In 1944, when the child was nine years old, "marked scoliosis of the dorsolumbar region" was noted. The right lower extremity was longer than the left. The length of the right femur was sixteen inches, the left fifteen and one-half inches. The right tibia was thirteen and one-half inches in length, the left twelve and one-quarter inches.

In November 1947, at the age of thirteen years, the patient entered the Orthopaedic Service of the Monmouth Memorial Hospital. At this time the scoliosis of the lumbar spine with convexity to the right was again noted. In addition, there was shortening of the left lower extremity, club-foot on the left, and multiple naevi of the skin of the back. Roentgenograms of the lumbar spine (Fig. 3) showed scoliosis with the concavity toward the left. All lumbar vertebrae were wedged quite uniformly, the left sides of the bodies being diminished in height. The left ilium was smaller than the right (Fig. 4). The distance (measured on the roentgenogram) from the origin of the ligamentum teres to the upper border of the sacro-iliac joint on the left was 9.4 centimeters; on the right it was 10.6 centimeters. The left twelfth rib was considerably smaller than its fellow on the opposite side.

DISCUSSION

The scoliosis in this case conforms to the deformity which would be expected if the growth of the epiphyses on the left side of the lumbar bodies had been retarded. The irradiation which the patient received at the age of nineteen months was directed to the left side of these vertebrae. It is practically impossible to compute accurately the difference in radiation dosage in the left and right sides of the involved vertebrae. However, it is reasonable to assume that the radiation from each of the three fields affected the left side of the spine substantially more than the right (Fig. 2).

Other factors indicate that this is not an "idiopathic" scoliosis, fortuitously occurring in a previously irradiated spine. It differs from the usual idiopathic scoliosis in several respects. The isolated lumbar curve (itself a rare occurrence) exactly follows the field of radiation, and the wedging is directed toward the irradiated side. In addition to the inhibition of growth in the left half of the vertebral bodies, there is inhibition of growth in the left twelfth rib, the left lumbar transverse processes, and the left ilium,—all included in the field of radiation. Moreover, in ordinary or idiopathic scoliosis, the wedging is maximal at the apex and diminishes gradually toward the ends of the curve. In this radiation-induced curvature, the wedging is uniform throughout the lumbar spine.

If the right pelvis of a normal subject is elevated, the lumbar spine presents a functional curvature, convex to the left, produced by wedging of the discs. (The discs would be thicker on their left sides.) In this subject, whose right pelvis is higher than the left, similar disc wedging is noted. This disc wedging may be considered as a functional curve, convex to the left, and due to the short left lower extremity. In the lumbar spine it is overcome by the much greater structural wedging produced by the radiation, the net result of the two opposite curves being a curvature convex to the right. However, in the thoracic spine, above the area where radiation has interfered, the upper end of the functional curve is apparent. Here, careful measurement reveals a wedging of the bodies of the tenth and eleventh thoracic vertebrae, higher on the *left* side, indicating that growth was inhibited by the pressure transmitted by the discs. This effect is probably present in the lumbar spine also, although overshadowed by the opposite radiation effect. Hence, far from producing the observed bone wedging, the short leg has tended, if anything, to minimize it by pressure retardation of epiphyseal growth.

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CALCIFIED ISLANDS IN MEDULLARY BONE*

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This paper is intended to comment on roentgenographic findings which, if neither rare nor morbid, are at least infrequently mentioned and incompletely understood. The findings in question are the asymptomic, unilateral, irregular, radio-opaque, insular lesions found in routine roentgenographic studies and usually classified by roentgenologists as calcified medullary defects of no pathological significance[13].

ROENTGENOGRAPHIC APPEARANCE

The defects are observed most commonly in the ends of the long bones, situated centrally in cancellous material. Bony trabeculae are not observed to pass through these islands. Their usual shape is oval, although many consist of amorphous, irregularly demarcated areas of calcification. Their density is homogeneous and they do not appear to be delimited by a capsule. The size varies from 0.5 to 7.5 centimeters in diameter. The cortical bone is not deformed and there is no evidence of expansile tendencies (Figs. 1-A to 1-D).

TABLE I

LOCATION AND INCIDENCE OF CALCIFIED MEDULLARY DEFECTS

Location	No. of Defects	Per cent.
Femoral neck	30	25.0
Femoral condyle	21	17.5
Wing of ilium	16	13.3
Proximal portion of tibia	15	12.5
Head of humerus	9	7.5
Femoral shaft	6	5.0
Calcaneus	5	4.2
Ischium	5	4.2
Sacrum	4	3.3
Head of fibula	3	2.5
Metacarpals	2	1.7
Humeral condyle	2	1.7
Patella	1	0.8
Vertebra	1	0.8
Total	120	100.0

In none of the cases observed were any symptoms referred specifically to the area of the lesion. The defect was noted in the course of diagnostic studies for arthritis and the osteochondritides, in views of the menisci and of fractures, and in gastro-intestinal series or genito-urinary surveys. No medullary island could be held definitely responsible for coincidental complaints.

INCIDENCE AND DISTRIBUTION

In order to determine the distribution and occurrence of the defects, a study was made of 6,000 roentgenograms of patients seen at the X-Ray Clinic of the Veterans Administration Hospital, Lake City, Florida. The location of 120 of the defects and their incidence are shown in Table I.

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TABLE II

PERCENTAGE OF INCIDENCE OF LESIONS IN SPECIFIC EXAMINATIONS

Location	Per cent.	Location	Per cent.
Femoral neck	11.0	Ischium	0.6
Femoral condyle	9.6	Sacrum	0.5
Wing of ilium	1.6	Head of fibula	1.5
Proximal portion of tibia	7.8	Metacarpals	1.3
Head of humerus	3.5	Humeral condyle	1.5
Femoral shaft	6.3	Patella	0.5
Calcaneus	6.3	Vertebra	0.3

Of the femoral necks examined by roentgenogram, 11.0 per cent. showed calcified medullary defects. Of the femoral condyles examined, 9.6 per cent. showed defects. The incidence of the lesions for all the osseous structures presenting defects has been recorded.

No lesions were demonstrable in specific examinations of the ribs, scapulae, clavicles, or thoracic vertebrae, or in 3,800 chest plates. In 63 per cent. of the abdominal flat plates in genito-urinary surveys and gastro-intestinal series, the bony pelvis, head and neck of the femur, and greater tuberosity were delineated clearly enough so that any defect present could be visualized. The over-all incidence of lesions on the right side of the body was 53 per cent.; 47 per cent. were demonstrable on the left.

All the patients examined were males. Their ages ranged from nineteen to eighty-three years, with most patients between thirty-five and thirty-nine years. With the exceptions noted under *Etiology*, no correlation could be drawn between the patient's antecedent or coexisting illness and the presence of the medullary defects. Two patients complaining of back pain had hemangiomata of the lumbar vertebrae; they likewise had multiple calcific defects in the femoral condyles and the femoral shaft (Figs. 2-A to 2-D). These two patients and one other having three lesions in the tibia were exceptions to the rule that most defects were unilateral and solitary.

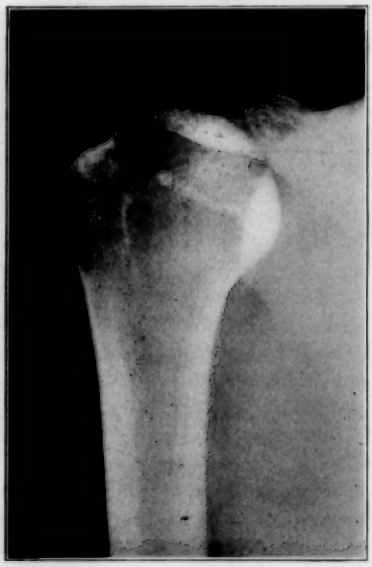

FIG. 1-A

FIG. 1-B

Fig. 1-A: Calcified defect in the proximal portion of the humerus.
Fig. 1-B: Calcified defect in the right wing of the ilium.

FIG. 1-C
Calcified defect in the distal end of the radius.

FIG. 1-D
Calcified defect in the inferior pubic ramus.

In none of the 120 cases showing defects was a history of submarine duty, deep-sea diving, or caisson disease elicited. A two-year follow-up study was possible in 11 per cent. of the cases; no change was seen in the defect at the end of the period.

ETIOLOGY

No satisfactory explanation as to the origin of the calcified medullary defects can be offered. Developmental factors may be involved, with faulty ossification of cartilage as the end result. Nutritional factors, such as scurvy and rickets, have been suggested, but a causal relationship has not been substantiated. The location around joints suggests trauma as an etiological factor, as does the unilateral location and the single lesion.

Twenty-four per cent. of the defects were found in patients exhibiting some form of the arthritides. Hirsch and Ryerson reported a case of massive aseptic necrosis of the femoral condyle in a patient with chronic arthritis. Axhausen and Bornstein and Plate

have attempted to explain chronic arthritis on the basis of primary aseptic necrosis of the bone, resulting from an interruption in blood supply at the junction of bone with the cartilage lining the joint. If we assume that the insular calcium deposits are bone infarctions or sites of organized aseptic necrosis, we would expect them to occur with frequency in arthritis, provided we accept the validity of the Bornstein-Plate theory. This is partly borne out in this small series of 120 cases.

Twenty-seven per cent. of the lesions occurred in patients in whom blood-vessel abnormalities were the foremost finding. The significance of this fact is difficult to evaluate. Again, if the calcific medullary defects are assumed to be small, asymptomatic, organized infarcts, the higher incidence of defects in diseases with vascular pathological changes seems logical. In three cases of infarction presented by Kahlstrom and one by Phemister, in which histological studies were done, arteriosclerosis was the outstanding pathological finding. Chandler likewise demonstrated bone infarcts in the head of the femur following obliteration of the nutrient artery.

The end arteries in bone were first described in 1875 by von Langer. Kistler, by rabbit experimentation, and Lexer and Nussbaum, with injection studies of humans, showed that the epiphyseal arteries undergo degeneration from transepiphyseal structures in childhood to end arteries in adulthood. These terminal vessels would be particularly prone to block; and subsequent anaemic infarction of the tissue receiving its vascular supply therefrom would be expected. It may be noted that 73 per cent. of the defects reported occurred in the "epiphyseal-line area", where a bland infarct could have been operative in an end artery.

DIFFERENTIAL DIAGNOSIS

Osteopoikilosis (osteopecilia; disseminated condensing osteopathy): This condition is characterized by asymptomatic spotted lesions of the bone, which are widely distributed throughout the body. The areas of condensation are reported to be hypertrophied trabeculae of the spongiosa, most commonly observed in the metaphysis or epiphysis. Archer found the condition in two brothers. Its only significance lies in differential diagnosis.

Osteoid Osteoma: This lesion may involve any bone, but its occurrence in the skull,

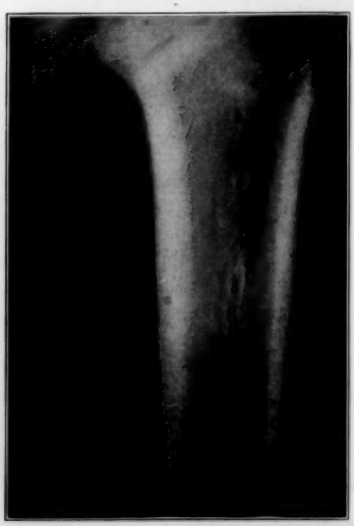

FIG. 2-A

FIG. 2-B

Fig. 2-A: Multiple lesions in the shaft of the femur.
Fig. 2-B: Multiple lesions in the area of the femoral condyle.

FIG. 2-D

FIG. 2-C

Fig. 2-C: Hemangioma in the thoracic spine, associated with multiple femoral defects, as seen in Fig. 2-A.
Fig. 2-D: Hemangioma in the lumbar spine, associated with multiple lesions in the area of the femoral condyle, as in Fig. 2-B.

scapula, and clavicle has not been noted. It is associated with well localized bone pain of several months' duration, usually in the younger age groups. Examination reveals swelling and tenderness, neither of which is found in the insular defects. The osteoid osteoma begins as a rarefied area in bone and progresses to dense calcification. A translucent center is frequently noted.

Osteogenic Sarcoma: This neoplasm, particularly of the sclerosing variety, is associated with severe pain, usually worse at night. The roentgenographic picture is that of an ill-defined bone lesion, showing cortical invasion or contact, in contra-distinction to the central, well defined appearance of the calcified defect.

Metastatic Lesions: Metastatic lesions should be carefully ruled out. Pain is a frequent

FIG. 3-A

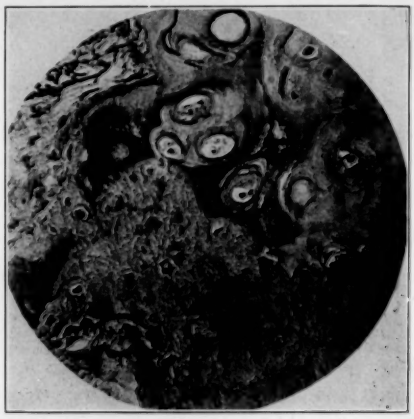

FIG. 3-B

Fig. 3-A: Case 1. Calcified medullary lesion (low-power magnification), illustrating the cortical shell with areas of new-bone formation and sclerosis.

Fig. 3-B: Case 1. Calcified medullary lesion (high dry magnification), illustrating young cartilage cells and fibrous bone marrow.

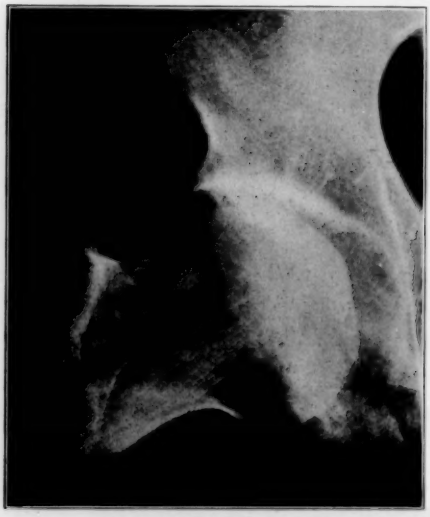

FIG. 3-C

FIG. 4-A

Fig. 3-C: Case 1. Lesion in the femoral neck.

Fig. 4-A: Case 2. Calcified medullary defect from the distal end of the femur.

complaint and the lesions are usually disseminated and multiple. Prostatic metastases most commonly lodge in the pelvis and lumbar vertebrae. They are frequently osteoplastic, but may show osteolysis on occasion, which aids in the differentiation of metastatic lesions from calcified medullary defects.

Chondrodysplasia: Ferguson stated that calcified islands should be included in this category, since they appear to be due to faulty ossification of cartilage. Hereditary dyschrondroplasia is frequently typified by roughly symmetrical masses of cartilage, originating in cortical bone.

Bone Infarct: According to Taylor, bone infarcts are usually confined to the ends of the long bones. This is also a region with an affinity for calcified defects. An area of density seems to surround the infarct, which suggests reossification and repair. An area of central translucence may also be observed.

Caisson Disease: Taylor, Kahlstrom, and Kahlstrom, Burton, and Phemister have postulated that caisson disease is a manifestation of bone infarction, compressed gas being the etiological agent. The description of the lesion in caisson disease is identical with that of bone infarction. The lesions are extensive, frequently bilateral, and multiple. An occupational history may be elicited.

CASE REPORTS

CASE 1. This man died of tuberculosis, no history of arteriosclerosis, arthritis, or heart disease being elicited.

J. K., aged thirty-two, a white male, was admitted to the Veterans Facility in July 1947. He had been discharged from the Army in 1945 and for the next two years had been in various tuberculosis sanatoria. Two weeks before admission he complained of pain in the left hip joint and of localized swelling and tenderness in the left groin.

The only significant findings in the past history were that he had had a tonsillectomy in childhood and that his right lung had been collapsed therapeutically in February 1946.

At physical examination he was markedly cachetic and appeared older than his stated age. Râles were heard over both lung fields. Pressure in the left renal area caused pain, which radiated into the groin. Beneath the left inguinal ligament was a swollen, tender area, which seemed to be fluctuant. The left hip was held in flexion and external rotation for comfort.

Roentgenograms disclosed bilateral pulmonary tuberculosis, and some obliteration of the iliopsoas shadow on the left. A calcified medullary defect was found in the neck of the right femur (Fig. 3-C). The patient failed rapidly and died four days after admission.

Postmortem examination revealed far-advanced pulmonary tuberculosis, and a tuberculous abscess

FIG. 4-B

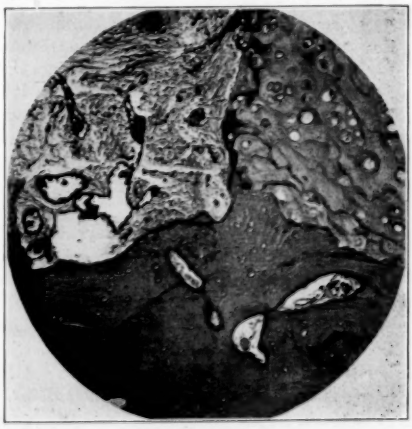

FIG. 4-C

Fig. 4-B: Case 2. Calcified medullary defect (low-power magnification), illustrating the cortical shell and showing the areas of sclerosis.

Fig. 4-C: Case 2. The specimen (high dry magnification) illustrating the necrotic and reossifying trabeculae and fibrous bone marrow.

pointing in the left femoral triangle. The cortex of the right femoral neck was removed over the area of the medullary defect, and an ovoid piece of tissue, one by two centimeters, was found in the cancellous bone. It was resilient, white, and was enveloped in a fine fibrous material. It offered definite resistance to cutting. The cut surface was white and gleaming, with an occasional area of cavitation; it was surrounded by grayish bone and was filled with fibrous tissue.

Microscopic sections (Figs. 3-A and 3-B) show an external fibrous coat over a peripheral shell of new bone undergoing ossification. Nests of young cartilage cells are present. Areas of excavation toward the center of the lesion are lined by necrotic bone undergoing resolution; the cancellous spaces are filled with fibrous bone marrow.

Case 2. In this case, a mid-thigh amputation was done for diabetic gangrene. There was no history of arthritis or of heart disease.

J. R., aged forty-nine, a negro male, veteran of World War II, was admitted with frank gangrene of the left lower extremity; he was cachetic and in diabetic coma.

The diabetes was controlled, and the patient was given therapy to improve his nutritional condition. Roentgenograms of the left lower extremity showed no arthritis in the knee joint. An incidental finding was a solitary calcified medullary defect, 2.5 by 3.5 centimeters, in the distal portion of the femoral shaft, just above the condylar region (Fig. 4-A). The outer margin was sclerotic in appearance and the center seemed to be undergoing lysis and reossification.

Amputation was performed at the mid-thigh. Studies of the calcified defect revealed a spheroid mass of sclerotic bone embedded in cancellous bone, but sufficiently demarcated by a fibrous coat so that it could be shelled out *in toto*. On cross section, it varied from a brilliant white resilient shell to a grayish necrotic center, crossed by trabeculae in various stages of repair.

Microscopic section shows an outer fibrous covering, beneath which lies a layer of new bone undergoing sclerosis (Figs. 4-B and 4-C). Young cartilage cells are scattered through the bony matrix. In the center of the lesion are trabeculae in various stages of necrosis and repair. The marrow cavity is filled with fibrous tissue.

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ACUTE PAIN IN THE WRIST AND HAND ASSOCIATED WITH CALCIFIC DEPOSITS

Report of Fifteen Cases

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Roentgenographically demonstrable calcific deposits have been found in many regions of the body, most commonly about the shoulder joint, frequently in and around the elbow, hip, and knee, but rarely at the wrist and palm. Sandström reported but two cases of calcific deposits at the wrist, as compared with 259 cases with involvement at the shoulder.

Milch and Green, in 1938, reported four cases of calcific deposits about the wrist in the region of the flexor carpi ulnaris, and concluded that these cases represented a definite clinical entity. They also included two cases in which the identical clinical picture occurred without calcification, and quoted a case treated by Steindler, in which calcification was found at the insertion of the flexor carpi radialis.

Cooper, in 1942, reported eight cases of calcareous tendinitis in the metacarpophalangeal region. Vasko, in 1946, reported a case of calcareous tendinitis in the flexor tendon of a finger.

This paper is concerned with fifteen cases of calcific deposits occurring about the wrist and palm,—eight on the ulnar side of the wrist, five on the radial side, and two in the palm of the hand in the region of the metacarpophalangeal joints.

The clinical picture was usually dramatic and acute, particularly in those cases with deposits at the wrist. All of the patients complained of severe pain in the region of the wrist of sudden onset and short duration. The pain was usually so acute that the patients were unable to sleep. There was associated swelling of the wrist, sometimes localized to the region of the deposit, but often including the entire dorsum of the wrist or hand. The patient held the wrist or fingers rigid, and attempted motion would cause severe pain. The tissues of the involved area were indurated and exquisitely sensitive, and the overlying skin was reddened. The two cases with calcification in the metacarpophalangeal region presented a similar but less severe picture; occasionally, milder symptoms were present in a case with deposits at the wrist.

Roentgenograms of the involved area show the shadow of a calcific deposit in the soft parts. The appearance of the calcification is often that of an area of homogeneous opacity, about three to four millimeters in diameter and rounded in shape; this, however, is not constant. Some of the deposits are extremely large and dense, measuring as much as one by two centimeters on the roentgenogram, whereas a few of them were only slightly larger than a pinhead, and might well be overlooked if the condition were not suspected. Subsequent roentgenograms showing the disappearance of the small opaque areas indicate their clinical significance. In some cases, the opaque areas were long, linear, and fragmented. The severity of the clinical picture was usually related to the size of the deposit; the larger deposits were associated with more pain, swelling, and redness and took somewhat longer to resolve. The small deposits, however, also produced an acute, painful, and active clinical course.

The precise location of the deposits is speculative in these fifteen cases, as none were explored surgically. Certainly as judged by the roentgenographic appearance, some of the deposits were much too large to be confined within the substance of any of the tendons at the wrist. Therefore, they probably lie within the peritendinous soft tissues,—that is, the tendon sheaths, bursae, or ligaments. This seems to be corroborated by Steindler's case, cited by Milch and Green, in which operation was carried out. In this case the tendon of the flexor carpi radialis was found to be uninvolved, but there was lime incrustation within the sheath of the tendon.

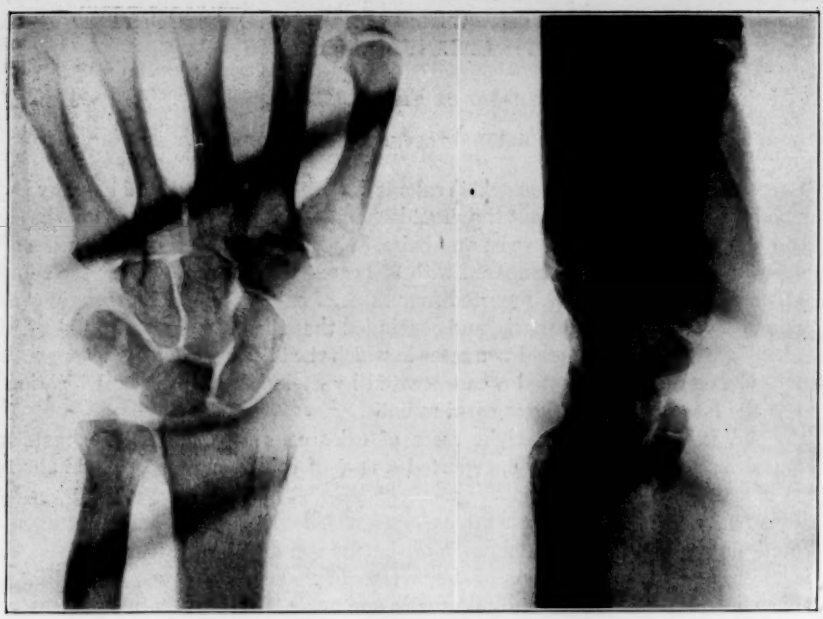

FIG. 1-A

H. B. A large, dense calcific deposit appears in the lateral view almost like an accessory bone.

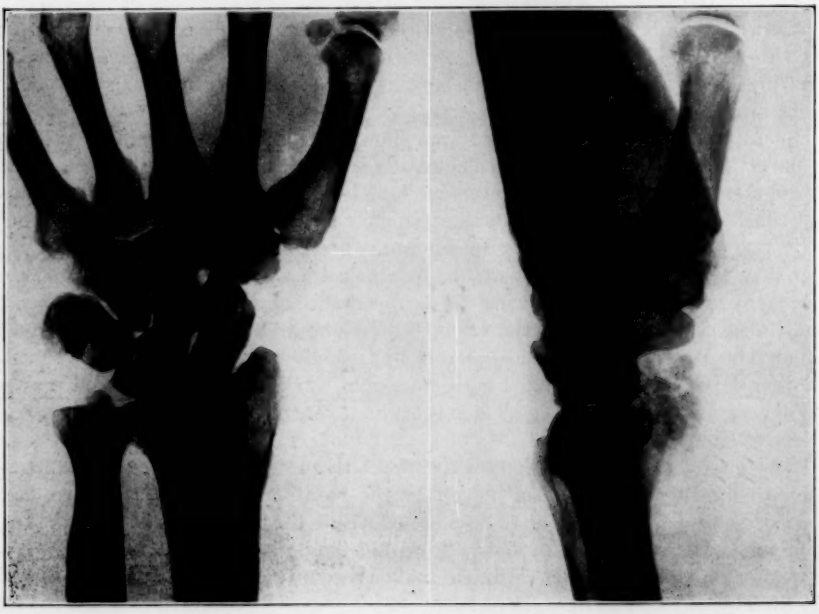

FIG. 1-B

Twelve days later, the deposit was becoming fragmented and, although it appeared larger, it was much less dense.

The etiology of the condition is obscure. Trauma apparently plays no real part, as it was not mentioned in the histories of nine of the fifteen cases and was of rather doubtful importance in the others. The concept of an asymptomatic deposit lying in relatively avascular and insensitive tendinous and ligamentous structures, with subsequent rupture of the deposit into highly sensitive synovial or bursal tissues, as occurs with calcific deposits in the shoulder, cannot be entertained here, as in none of these cases was the deposit asymptomatic. M. M. Pomeranz, M.D.,* has no recollection of ever having seen an asymptomatic deposit about the wrist or hand, despite innumerable roentgenograms examined for many other conditions. With regard to sex, the cases were about evenly divided; eight of the patients were males and seven were females. Their ages varied from thirty to sixty-nine years, the largest group being in their forties.

FIG. 1-C

Nineteen days later, the deposit was considerably smaller; clinically, it was asymptomatic. The deposit subsequently disappeared.

What does appear to be of great significance is that in this small group of patients, acute calcific bursitis of the shoulder developed in three, either simultaneously or shortly afterward. Sutro and Cohen, in their paper on calcification of the tendinocapsular tissues, felt there was a strong likelihood of an underlying vitamin deficiency, possibly of vitamin E, since degeneration, necrosis, and calcification of the voluntary-muscle fibers developed in animals kept on a diet deficient in vitamin E. Although there is no clear proof of the importance of this specific vitamin, some general disorder or deficiency appears to be the underlying cause of this syndrome.

In one of Milch and Green's cases, an acute calcific deposit developed at the insertion of the triceps. Coincidence apparently does not account for the relatively high incidence of multiple deposits in the body, and points away from purely local factors as the cause of the deposits.

The diagnosis of calcific deposits is made easily if the possibility of this condition is

FIG. 2-A

T. M. A long, linear calcification is demonstrable in the lateral and anteroposterior views

* Roentgenologist of the Hospital for Joint Diseases.

FIG. 2-B

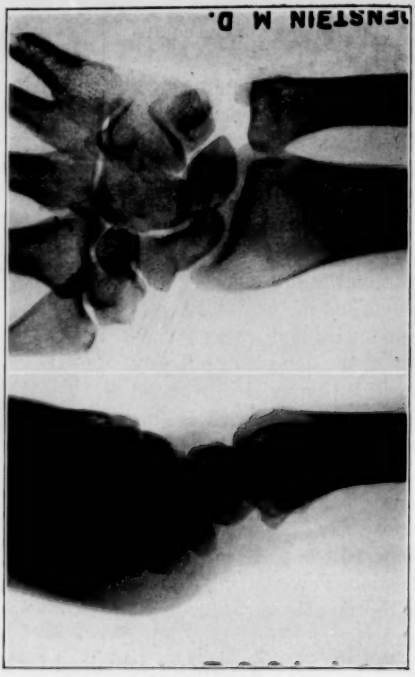

FIG. 2-C

Fig. 2-B: Eight days later, the distal portion of the deposit had become fragmented and the proximal portion had apparently been absorbed.
Fig. 2-C: Eighteen days later, the deposit had completely gone.

kept in mind. The localized swelling, sensitivity, and redness, however, have caused confusion with infection, and two of the patients in this series had received penicillin injections. The pain is usually much more severe with calcific deposits than with an abscess, and the rather typical locations (atypical for a carbuncle or local abscess) plus the absence of lymphangiitic streaking, glands, or abrasion of the skin should make the diagnosis possible. Of course, the roentgenographic findings establish the diagnosis, but in the few cases where the deposit is small, it may easily be overlooked. Occasionally, fracture or osteomyelitis is entertained as a diagnosis, but these are easily excluded.

The prognosis of this syndrome is excellent. All of the patients studied made a prompt and rapid recovery. Apparently the process is self-limited and the deposits disappear spontaneously within a reasonably short time,—in less than a week in some cases and in two or three weeks in others. In a few cases, where the calcific deposits were quite large, more time elapsed before they disappeared completely. Within a short time, however, the deposits became much smaller and the clinical signs and symptoms had improved markedly.

In view of the fact that the condition is apparently self-limited and recovery is spontaneous, both clinically and roentgenographically, any form of treatment which offers symptomatic relief is indicated. In the acute phase, the pain is so extreme that it is not relieved by narcotics alone. If, however, the wrist and hand are immobilized by means of a plaster bandage, there is immediate alleviation of pain. The cast is maintained until the patient reports that there is no pain and he can actively move his fingers without any "twinges". This usually requires about seven to ten days. After removal of the plaster, there is usually slight sensitivity to firm pressure over the site of the deposit, but this rapidly disappears when local heat is applied.

FIG. 3-A

J. A. A roentgenogram in the oblique view shows a "fluffy" oval deposit anterior to the third metacarpal head, with two small areas of increased density, one probably representing a sesamoid bone.

FIG. 3-B

J. A. Twenty-nine days later, the deposit had gone. The sesamoid, of course, remained.

FIG. 4

F. T. A kidney-shaped deposit can be well visualized, to the radial side of the greater multangular.

In three of the cases, the involved area was infiltrated with procaine solution. Usually the area is so sensitive that the insertion of a needle appears to be too painful a procedure to be justified in this self-limited disease. In one case, infiltration was done through a fine hypodermic needle at the onset of the condition and a plaster was applied. In two other cases, it was done after removal of the cast, when the deposit was still present and the region was quite indurated. In no case was any attempt made to remove the deposit. Apparently any form of reasonable treatment will lead to a cure, but the application of a plaster bandage for a week or two, followed by a short period of physical therapy or a few infiltrations with procaine solution, affords comfort to the patient while the process is running its course.

The fifteen cases were divided into the following groups:

A. Those cases with the deposits along the course of the flexor carpi ulnaris at and about the pisiform bone (eight cases).

B. Those cases with the deposits along the course of the flexor carpi radialis at or about the greater multangular (five cases).

C. Those cases with the deposits in the palmar aspect of the hand at one of the metacarpal heads (two cases).

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DISLOCATION OF FIRST CUNEIFORM IN TARSOMETATARSAL FRACTURE-DISLOCATION

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The reduction of tarsometatarsal dislocations usually does not present a problem. In some of the standard textbooks on fractures, including that by Watson-Jones, the condition is not described. In others it is well outlined, but occasionally open reduction is described as necessary, although the indications are not given[2]. The second case presented here shows that replacement of the first cuneiform is the chief problem in reduction. When the articulation of the first cuneiform and the first metatarsal remains intact, but that of the navicular and the first cuneiform is dislocated (with other possible fracture-dislocations involving the remainder of the tarsus and metatarsus), reduction can be obtained either by manipulation or by the use of traction with Kirschner wires through the calcaneus and the metatarsals, followed by manipulation. However, difficulty in reduction is encountered when there is disruption of the articulation of the first cuneiform and first metatarsal with outward rotation of the first cuneiform, separating it from the second cuneiform. In this event, one must resort to open reduction. The primary problem in this latter condition is the position of the anterior tibial tendon.

The normal insertion of the anterior tibial tendon is to a facet on the anterior and

FIG. 1-A

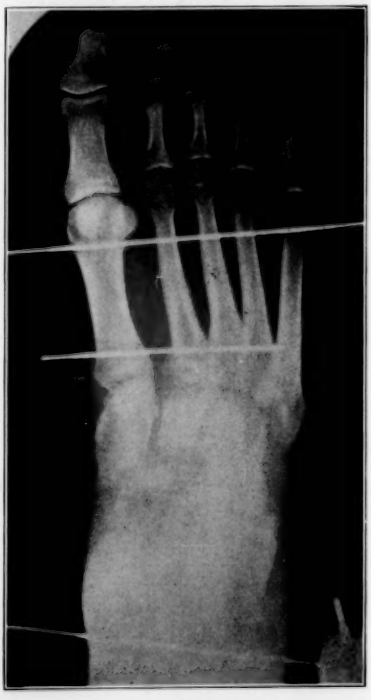

FIG. 1-B

Fig. 1-A: Showing tarsometatarsal dislocation with the articulation of the first cuneiform and the first metatarsal remaining intact.

Fig. 1-B: Showing reduction by means of skeletal traction.

FIG. 2-A

FIG. 2-B

FIG. 2-C

Fig. 2-A: Tarsometatarsal dislocation in which the articulation of the first cuneiform and the first metatarsal is disrupted, with medial dislocation of the first cuneiform.
Fig. 2-B: Shows failure of reduction by skeletal traction.
Fig. 2-C: Post-reduction roentgenogram. A Kirschner wire was inserted into the first metatarsal and was anchored in the plaster as a temporary measure.

inferior medial aspect of the first cuneiform and the medial side of the base of the first metatarsal[1]. As the first cuneiform is displaced in the process of dislocation, its ligamentous attachments are torn from the first metatarsal and the second cuneiform, and the bone assumes a position of external rotation. The portion of the anterior tibial tendon which remains attached to the first metatarsal slips between the first and second cuneiforms. Attempts to secure reduction by increasing the traction on the first metatarsal will fail, irrespective of the degree of traction or the amount of manipulation, since the anterior tibial tendon will remain interposed between the first and second cuneiforms.

Roentgenograms are presented to illustrate this variation within the general classification of tarsometatarsal fracture-dislocation. In the usual type of injury, the articulation of the first cuneiform and the metatarsal is not disrupted (Figs. 1-A and 1-B). This patient had an extensive injury with fracture-dislocation of the articulation of the navicular and first cuneiform, as the result of a collision between a motorcycle and an automobile. The articulaton of the first cuneiform and the first metatarsal remained intact. Reduction was obtained by skeletal traction (Fig. 1-B). Unfortunately, follow-up studies in this case could not be obtained.

The second patient was also involved in an automobile collision. In addition to tarsometatarsal fracture-dislocations, he also had primary dislocation of the first cuneiform with separation of the first and the second cuneiforms (Fig. 2-A). Skeletal traction was attempted, but the deformity persisted (Fig. 2-B), necessitating open reduction.

The operative procedure consisted of a dorsomedial incision, centered over the articulation of the first cuneiform and the metatarsal. The anterior tibial tendon was lifted out of the interval between the first and second cuneiforms and was slipped over the medial aspect of the first cuneiform. A Kirschner wire was then inserted longitudinally from the first metatarsal into the first cuneiform to maintain the reduction (Fig. 2-C).

At follow-up examination, two years after injury, the patient was leading an active life as a university student, with athletics including boxing and football. He believed that his ability to kick the football had improved since the accident, but that his general agility had decreased. He had no pain.

Examination showed that he walked with a slight left-sided limp. There was definite flattening of the medial longitudinal arch of the left foot, so that the first cuneiform was the most prominent bony landmark on the medial superior aspect of the foot. The fore part of the foot was in abduction of 10 degrees in relation to the hind portion.

Subtalar and ankle movements were carried through a normal range. Mid-tarsal movements were markedly restricted. There was three-quarters of an inch of atrophy of the left calf, as compared to the right. The patient was able to stand and walk on the toes of both feet, but his height was diminished when he walked on the left foot.

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MELORHEOSTOSIS

Relief of Pain by Sympathectomy *

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Melorheostosis is a rare condition, characterized by hyperostosis of certain bones or parts of bones. The distinguishing features are: (1) restriction of the involvement to the bones of one limb; (2) distortion of the outline of the affected bone by the flowing hyperostosis; (3) pain, occasionally severe, but usually dull and aching in character; and (4) stiffness and limitation of motion in the joints of the involved limb.

Pain, the most frequent symptom, occurs in half of the cases, particularly in the older patient. It is usually dull and aching in character; seldom is it severe. Léri and Lièvre considered it to be unimportant. Limitation of motion of the joints of the affected limb is more prone to occur in late cases, and is thought to be due to the excessive formation of dense bone in the immediate neighborhood of a joint and to the deposition of bone in adjacent soft tissues. In the case to be presented here, no such periarticular deposits were present, yet motion was markedly restricted. This restriction, we believe, was due to an ischaemic phenomenon, since sympathectomy increased the range remarkably. The involved limb may also show swelling, oedema, induration, and skin changes, such as scleroderma. Hypo-aesthesia and paraesthesia are uncommon. The diagnosis is relatively easy, because of the characteristic roentgenographic findings, limited to one limb.

A review of the literature indicates that methods of treatment of melorheostosis remain obscure. Few of the papers written upon this subject allude to therapy, and then only briefly. The treatment is necessarily symptomatic, since the etiology is unknown. The symptoms and signs requiring treatment are mainly two,—pain and limitation of motion. Most patients will tolerate the latter, but pain is the symptom that usually brings them to the doctor.

The degree of pain in this affliction apparently has wide variance, as one can readily see in reviewing the cases reported. Léri and Joanny stated that pain was unimportant, but reported the case of a woman, thirty-nine years of age, who had had a constant, dull, annoying ache in the left shoulder for eight years. At a later date Léri, working with Loiseleur and Lièvre, reported the case of a thirty-year-old cleric with sharp, lancinating pains in the wrist and hand. Kraft likewise reported the case of a forty-year-old man with sharp, lancinating pains throughout the left upper extremity. In the case of a carpenter, thirty-eight years old, reported by Moore and de Lorimier, the same lancinating, intermittent, sharp pains occurred in the left upper extremity; in addition, a dull aggravating ache was present in the shoulder region,—a distribution not unlike that in the case presented here. Lewin and MacLeod's patient, a man of thirty-five years, had complained of a constant, dull pain which had become progressively worse since he was ten. These few examples indicate that in some of the cases of melorheostosis, like that reported here, pain cannot be ignored.

The other prominent symptom, limitation of motion, is reported almost universally by all authors. Kraft considered it the most annoying symptom. It, too, requires therapy in order to prevent increasing disability.

With regard to methods of treatment, Dillehunt and Chuinard reported that traction

* Sponsored by the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are a result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

had been employed for the relief of pain in a ten-year-old boy with involvement of the left lower extremity. Kraft stated that "no definite therapeutic achievements" had been reported; however, improvement was observed in one of his two cases when repeated roentgenograms were taken. No further observations along this line were found in the literature.

Valentin and Kahlstorf, with several others, reported relief from heat and physical therapy. Nowhere could the authors find mention of surgical treatment having been employed, except for the correction of existing deformities. The literature indicates that the one reason for not utilizing surgery was lack of symptoms severe enough to warrant more than physical therapy, occasional traction, or explanation to the patient of the nature of his disease. However, in several of the cases, including the one presented here, pain appeared to require more than simple palliative treatment.

The authors believe that the symptoms in the case to be reported were on a basis of ischaemia secondary to peripheral vascular disturbance. The presence of pain, swelling, discoloration, stiffness, abnormal temperature changes, and profuse palmar perspiration confirm this belief. Barker and others regard these signs and symptoms as indicative of peripheral vascular disease. The authors are unable to say whether the bone or the vascular changes occurred first.

CASE REPORT

V. H., a fifty-year-old white male, was admitted to Kennedy Veterans Administration Hospital for the first time on December 14, 1947, with the chief complaint of pain and stiffness of the entire right upper extremity. He dated the onset of his symptoms to 1917, at which time a fellow soldier had attempted to take his hat cord from him. A scuffle ensued and the cord became looped around his right wrist, in tourniquet fashion. His hand and wrist were swollen for several days and quite painful. As the swelling subsided, sharp, lancinating, evanescent pains began in the region of the medial epicondyle of the humerus, radiating down the lateral aspect of the forearm to the hand and into the long finger, especially to the proximal interphalangeal joint. Shortly thereafter, the patient noticed that the right hand was becoming larger than the left; approximately one year later, his mother noted that his right ear was larger than the left. There has since been a gradual increase in size of both the right upper extremity and the right ear.

Since that time the patient has never been entirely free of pain; the fact that he was able to carry on and earn a living, he attributes solely to his youth and vigor.

In 1945, during one of his many visits to a doctor in an effort to find relief from pain, a growth was excised from the volar aspect of his right wrist; no improvement resulted. This growth was possibly one of the hard nodules, frequently found in the subcutaneous tissues of the involved extremity. One year later, the scar was excised by another doctor in a further unsuccessful attempt to obtain relief from the pain.

On admission, the patient complained of a constant dull ache (like a toothache) in the region of the right shoulder. In addition, he described sharp, lancinating pains, ranging from the shoulder to the finger tips; they did not assume any definite pattern, but at one moment were shooting proximally and at the next moment distally. However, they seemed to be more concentrated about the wrist and radial side of the hand. The pains were not influenced by weather, heat, exercise, or alcohol. The patient had learned to fall asleep by ignoring the pain, but always found it present when he awakened. When the pain was especially bad, touching the hand or even laying it against a pillow was unbearable. On occasion, particularly during the night, paraesthesia would develop in the hand and wrist, requiring exercise. (Kraft described a similar case.) He had lost considerable gripping power in the hand, due to stiffness and loss of motion, and stated that he was unable to "hold a job".

The family history and past history were negative, except that he had sustained a traumatic mid-carpal amputation of the left hand, excluding the thumb, in 1924, while working as a flour miller.

Physical examination at the time of admission revealed a well-developed, well-nourished, cooperative and intelligent white male, fifty years old, not appearing acutely or chronically ill and in no apparent pain. The head showed nothing of note, with the exception of macrotia on the right. This ear was dusky red in color and warmer to palpation than the left. It measured three inches in length, as compared with two and three-quarters inches for the left ear. The four fingers, their metacarpals, and the distal row of carpals were absent on the left; the scar was well healed and the patient had good pincers motion of thumb and stump.

The remainder of the pathological findings were limited to the right upper extremity. There was a normal range of painless motion in all joints, except the metacarpophalangeal and interphalangeal joints. Flexion was limited in all of these joints to the extent that the patient was unable to approximate the finger tips and palm, making it impossible for him to grip effectively an object smaller than a flashlight handle. No pain was elicited on motion or palpation.

FIG. 1

Roentgenogram of scapula and proximal end of humerus, showing increased density at the base of the coracoid and spotty areas in the head of the humerus.

FIG. 2

Roentgenograms of forearm show thickening of radial cortex, narrowing of medullary canal with obliteration in proximal third, and striations in cancellous bone distally.

Comparative measurements were as follows:

	Right (Inches)	*Left (Inches)*
Length of upper extremity	22⅜	22⅜
Circumference 7 inches below acromion	13⅝	11⅝
Circumference 5 inches below olecranon	11	9⅛
Circumference at wrist	7⅝	6⅝
Circumference at middle of proximal phalanx of thumb	3⅝	2¾

There was increased dependent rubor on the right and increased sweating, limited to the entire palmar area of the right hand. The temperature was the same in both extremities; however, the patient often complained that the right hand was cold. Reflexes were equal and active bilaterally. Irregular, bony-hard ridges were palpable along the bones shown by roentgenogram to be involved. There was a well-healed, vertical, slightly tender scar, one and one-half inches in length, on the volar aspect of the right wrist.

Roentgenograms of the entire body, taken on more than one occasion, disclosed areas of increased density in the right scapula in the region of the coracoid process (Fig. 1). Mottled areas of increased density were seen in the proximal end of the right humerus. In the forearm there were linear areas of increased density, thickening of the cortex of the radius, and narrowing of the medullary canal with complete obliteration in the proximal third (Fig. 2). The cortex of the navicular, greater multangular, first and second metacarpals, and all phalanges, with the exception of those of the little finger, was also greatly thickened (Fig. 3).

During the patient's hospital stay, from January 20 to March 11, 1948, treatment consisted of whirlpool baths, passive exercises, and occupational therapy (weaving two hours daily on a floor loom). The range of finger motion improved moderately, but there was no lessening of symptoms.

On February 21, novocain was injected periarterially at the elbow. This produced increased warmth and cessation of sweating peripheral to the block, but no change in symptoms. Empirically, the patient was given 100 milligrams of thiamin chloride daily and an occasional anodyne. Only the anodynes gave temporary relief.

He was discharged on March 11, as having received maximum benefit, but returned to the Hospital on May 8, 1948, because continued pain prevented him from earning a livelihood. Re-examination revealed no change. At this time, a stellate-ganglion block was done on the right. There was a marked objective response,

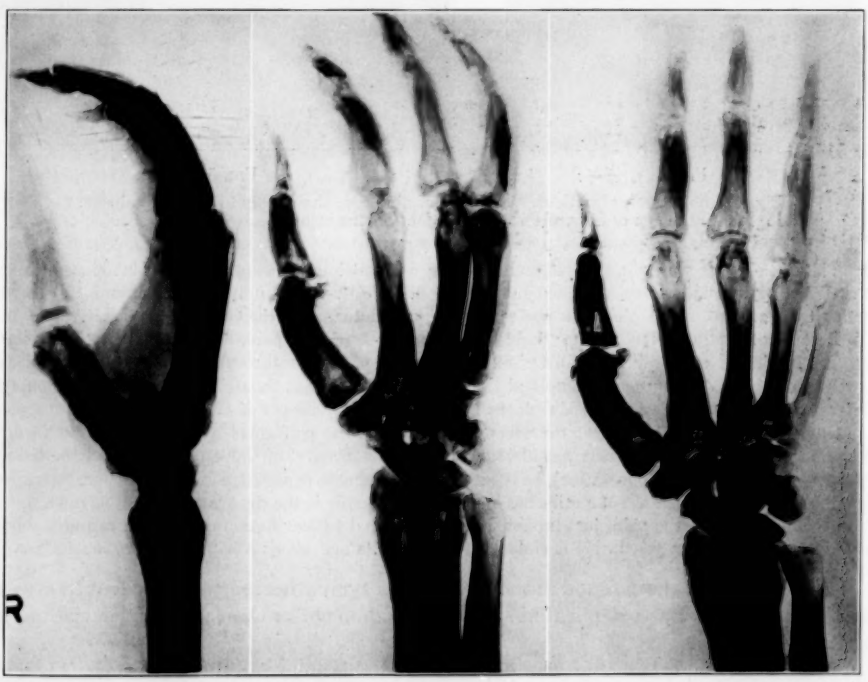

FIG. 3

Roentgenograms of hand reveal cortical thickening with bone enlargement, as well as encroachment on the medullary canal in all except the fifth ray.

including dryness of the hand, increased warmth of the right upper extremity, and Horner's syndrome, and the patient experienced almost complete relief from pain for several days. On the basis of this finding, he was seen by the general surgical consultants for the possibility of thoracic sympathectomy. A thoracic block of the right first, second, third, and fourth sympathetic ganglia was performed, metycaine being used. A marked objective response was again observed; subjectively, however, there was no appreciable alleviation of the pain. The general surgical consultants decided, on the basis of their findings, that sympathectomy was not indicated. Members of the Neuropsychiatric Service concluded that the pain was not on a neurotic basis.

FIG. 4

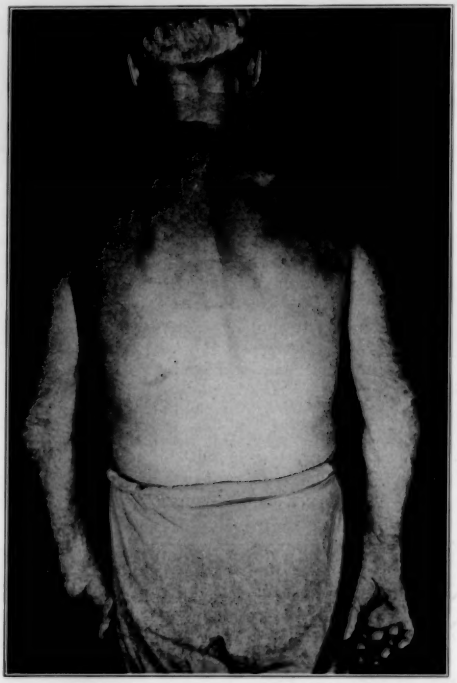

FIG. 5

Fig. 4: Photograph of patient, at the age of nineteen, shows ears to be of equal size.
Fig. 5: At the age of fifty, macrotia is evident on the right.

Thiamin chloride was administered as before, but without improvement. (The patient himself experimented with alcoholic beverages without noticeable relief.) He was again discharged on June 10, since no further treatment seemed feasible, but was seen at frequent intervals in the Orthopaedic Clinic.

Because of continued inability to "hold a job", due to persistent pain, he requested another stellate-ganglion block and was readmitted on October 20. In spite of equivocal results from sympathetic blocks, it was agreed by the orthopaedic group and the general surgeons that thoracic sympathectomy should be performed, since sympathetic novocain blocks had been the only means of offering any relief from pain.

On November 24, 1948, a right thoracic sympathectomy was performed by the method described by White and Smithwick. The patient was discharged from the Hospital on January 5, 1949. At the time of writing (twelve months after operation), he is still free from pain. As expected, the hand is dry and is warmer than its counterpart. The range of motion has increased remarkably in the right hand, so that he can approximate the finger tips to the palm just proximal to the proximal palmar flexion crease, and can grip solidly an object smaller than a pencil. He is elated with the results and seems a happier, more hopeful person.

No mention has been found in the literature of sympathectomy as a form of treatment for this condition. Putti implicated sympathetic damage as the cause, but suggested no treatment.

Thoracic sympathectomy was performed on this man for three reasons: (1) Some degree of relief had been obtained from stellate-ganglion blocks and thoracic sympathetic blocks; (2) anodynes, physical therapy, et cetera, had already been tried unsuccessfully; (3) the patient was unable to concentrate on any type of work because of the pain, and,

therefore, requested that the operation be performed. The results were dramatic. There was immediate, complete relief from pain and return of function to a crippled hand.

The significance of the accompanying anomalous macrotia on the right is not known. This patient's ears were of equal size until the age of twenty or twenty-one (Fig. 4), when his mother first observed enlargement on the right. The fact that the ear enlargement occurred at the same time as the pain and enlargement of the right upper extremity strongly suggests that the macrotia is a part of the process; however, roentgenograms do not show any abnormal changes in the cartilage.

Others have reported cases with associated anomalies (Muzii's patient, a ten-year-old girl, had craniostenosis), to support the theory of congenital origin of the disease. However, the purpose of this paper is not to establish a theory as to etiology, but to present a case benefited by extirpation of the sympathetic nerve supply to the involved quadrant.

SUMMARY

The case reported is characteristic of melorheostosis in that the lesions were confined to the right upper extremity. The clinical course, with gradual progression and increasing pain, is also typical. Treatment by thoracic sympathectomy gave dramatic relief from symptoms. As far as can be determined from the literature, this is the first form of treatment which has been of lasting value in this rare and painful condition.

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HEALING OF BILATERAL FRACTURE OF THE PARS INTERARTICULARIS OF A LUMBAR NEURAL ARCH

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In February 1947, the author encountered a case of fresh bilateral fracture of the pars interarticularis of the third lumbar neural arch, without dislocation of the involved vertebral body [1]. A man, twenty-two years old, had suffered multiple bone injuries when his jeep overturned. He was seen immediately after the accident and, because his pelvis had been broken on both sides, was placed on a Stryker frame. Portable roentgenograms of his spine, made with the patient thus recumbent on the frame, showed the unusual complex of fractures involving both isthmi of the third lumbar neural arch, without dislocation of its vertebral body.

The patient's other bone injuries—fracture of the left scapula, dislocation of the left shoulder, fractures of the transverse processes of the fourth and fifth lumbar vertebrae, and fractures through both rami of both sides of the pelvis—healed in the usual time without complications. Because of the spine injury, however, the period of recumbency was extended to seventeen weeks. Roentgenograms at the end of that period showed obliteration of the fracture lines.

At the time of this writing, two years and four months have elapsed since the injury. Questions have been raised as to whether the fracture sites, having *apparently* undergone osseous healing during the period of recumbency, would actually be absorbed under the strain of continual weight-bearing in the erect position and would eventually show defects in the neural arch; and whether, in the event of such absorption, these defects might not be similar to those usually associated with the concept of presumably congenital spondyloschisis.

The patient was re-examined on May 3, 1949. He had worn a Taylor spine brace for six months following recumbency, had been regularly employed at clerical work, and had no symptoms referable to his spine or other bones.

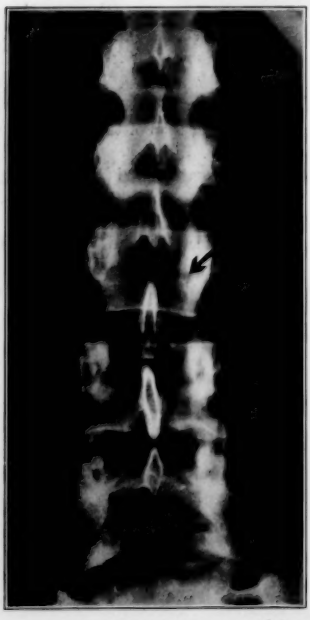

FIG. 1-A

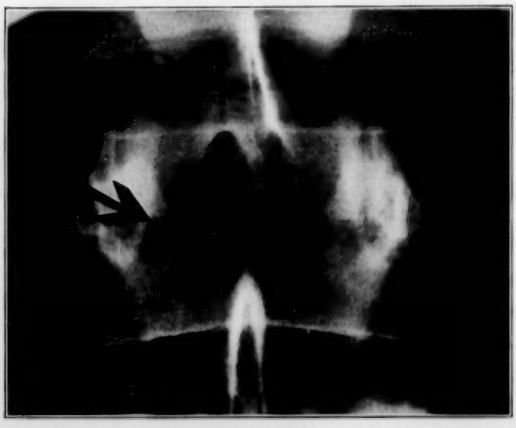

FIG. 1-B

Fig. 1-A: May 3, 1949. Anteroposterior view of lumbar spine, showing healed sites of laminar fractures of the third lumbar vertebra.

Fig. 1-B: Enlarged anteroposterior view of the third lumbar vertebra, showing replacement of fracture lines with normal trabecular pattern.

Fig. 1-C: Lateral view of the lumbar spine, showing osseous integrity of the former fracture site, absence of deformity, and no evidence of forward displacement of the involved vertebra.

Fig. 1-D: Enlarged right postero-oblique view, showing bone continuity at the healed site of the fracture through the pars interarticularis of the third lumbar vertebra.

Fig. 1-E: Enlarged left postero-oblique view, showing healed fracture site in the left pars interarticularis with osseous continuity and normal alignment.

FIG. 1-C

FIG. 1-D

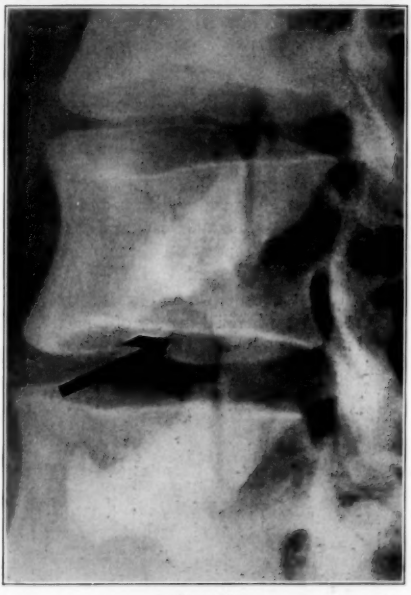

FIG. 1-E

The roentgenograms (Figs. 1-A, 1-B, 1-C, 1-D, and 1-E) continued to show osseous healing without deformity.

1. ROCHE, M. B.: Bilateral Fracture of the Pars Interarticularis of a Lumbar Neural Arch. J. Bone and Joint Surg., **30-A:** 1005–1008, Oct. 1948.

UNICAMERAL BONE CYST

Report of an Unusual Case

BY CHARLES G. HUTTER, M.D., HOLLYWOOD, CALIFORNIA

In recent years the unicameral bone cyst (a cyst of one chamber) has become recognized as a separate entity from those lesions formerly classified under the general term of localized fibrocystic disease. This differentiation has been based upon the distinctive roentgenographic and pathological features of the lesion, which have been concisely and clearly described by Jaffe and Lichtenstein. The observations of these authors provide strong arguments for classification of the condition as a separate disease entity.

The roentgenographic criteria of the lesion have been summarized as follows by Jaffe and Lichtenstein: "A characteristic feature of solitary unicameral cyst of long bones is the location in the shaft of the bone, near or relatively near to an epiphyseal cartilage plate. Indeed, in a young subject the cyst rarely (if ever) transgresses the plate so as to be both in the shaft and in the neighboring epiphysis. . . . A cyst developing in a long bone after fusion of the epiphysis with the shaft may be found to involve both part of the shaft and the adjacent epiphysial end of the bone." This roentgenographic feature has been of great assistance in differentiating this cystic lesion from giant-cell tumor of bone.

The following case is reported because of the unusual roentgenographic appearance and the pathological extension of a unicameral bone cyst into the adjacent epiphysis during the growth period. A review of the recent literature has failed to disclose any record of a similar case.

The patient was a white girl, six and one-half years old. The parents had first noticed a lump over the medial aspect of the tibial table, four months prior to hospital admission of the child. There was no associated change in color or temperature of the overlying area of skin. Whenever the patient injured the swelling, it remained painful for several days. She had injured it two months prior to admission, and a cast had been worn for that interval of time to protect the joint.

There was no familial history of bone disease. The child's development had been normal and she had suffered no serious illness or injury.

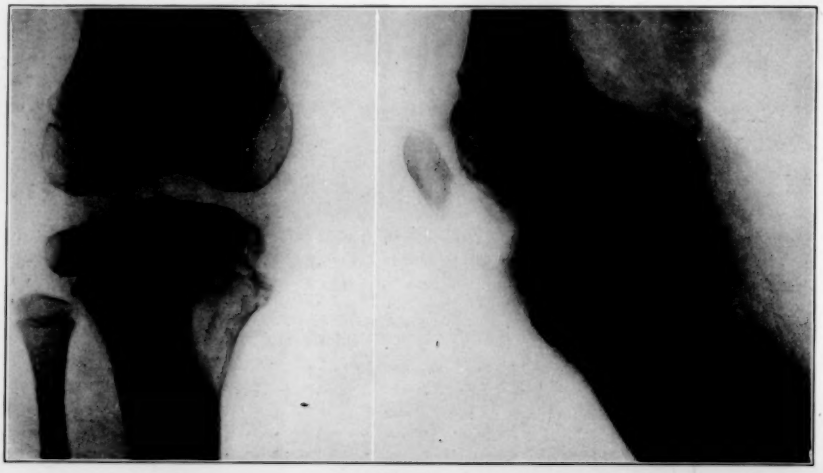

Fig. 1

Unicameral bone cyst extending through the epiphyseal plate and into the epiphysis.

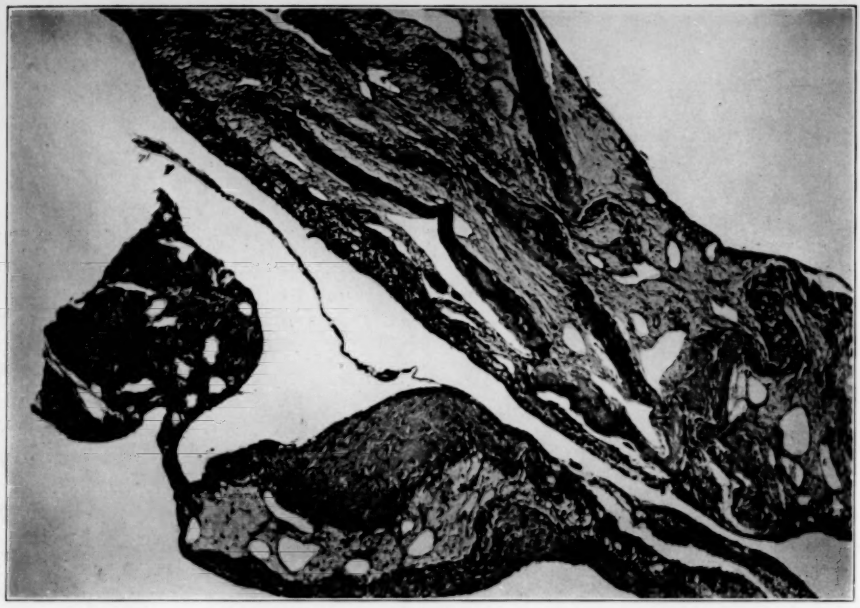

FIG. 2

Photomicrograph (× 70) shows new-bone formation and a fibrous-tissue stroma which make up the cyst lining.

Physical examination revealed a healthy, well-developed, slightly overweight child. Her integument and external appearance were normal, as were the heart, lungs, and reflexes. The right extremity was the same size and shape as the left. Over the right medial tibial table there was a very slight swelling, which was firm and not sensitive to pressure. The overlying skin was freely movable and normal in appearance. Flexion of the knee was limited to 70 degrees by pain in the posterior aspect of the joint. There was no limitation of extension.

Blood examination, including chemical studies of the serum constituents, was within normal limits.

Roentgenograms showed an area of rarefaction in the medial portion of the right tibia, at the knee joint. This was a single discrete area, sharply demarcated from the adjacent normal-appearing tibia, and apparently contiguous with a similar area of rarefaction at the medial edge of the epiphysis (Fig. 1). One portion of the cortex appeared to have been eroded by the underlying process. A skeletal survey of the remaining bones failed to reveal other bone defects.

At operation, the lesion was approached through an incision over the mass. The cortex was as thin as tissue paper, but had not been eroded through by the lesion. When the cystic area had been opened, serosanguineous fluid was obtained. The mass, when evacuated, was found to consist of a single cystic cavity, being free of bony trabeculae crossing it or of fibrous-tissue septa. The cavity extended into the epiphysis by means of a two-centimeter defect in the epiphyseal plate, and was continuous with a cavity on the medial aspect of the tibial epiphysis. There was very little material forming a lining membrane to the cyst, and curetting of this lining produced only small amounts of dense fibrous-like tissue.

Cancellous bone, obtained by trephine curettage through a one-inch incision over the iliac crest, was packed into the defect in the epiphysis and the tibia, and the wound was closed.

At microscopic examination, the specimen consisted of small fragments of fibrous tissue. There was evidence of osteoid formation in some areas. Upon one edge there was an alignment of cells, suggesting the formation of a lining membrane. There were areas of increased vascularity and some evidence of recent hemorrhage (Fig. 2).

The findings were consistent with those of a unicameral bone cyst.

Three years later the lower extremities were of equal length and size. There was no evidence of growth arrest of the tibial epiphysis, and both tibiae measured the same length. Roentgenograms revealed that the cystic defect, formerly seen in the epiphysis, had completely disappeared. There were, however, still some areas of rarefaction in the shaft of the tibia, probably due to residual material from the lining membrane of the cyst, which had escaped curettement. These areas of rarefaction appeared to have grown away from the epiphysis, suggesting that there had been growth of the bone in the intervening years. The epiphyseal cartilage plate was normal in appearance and there was no evidence of arrest of growth (Fig. 3).

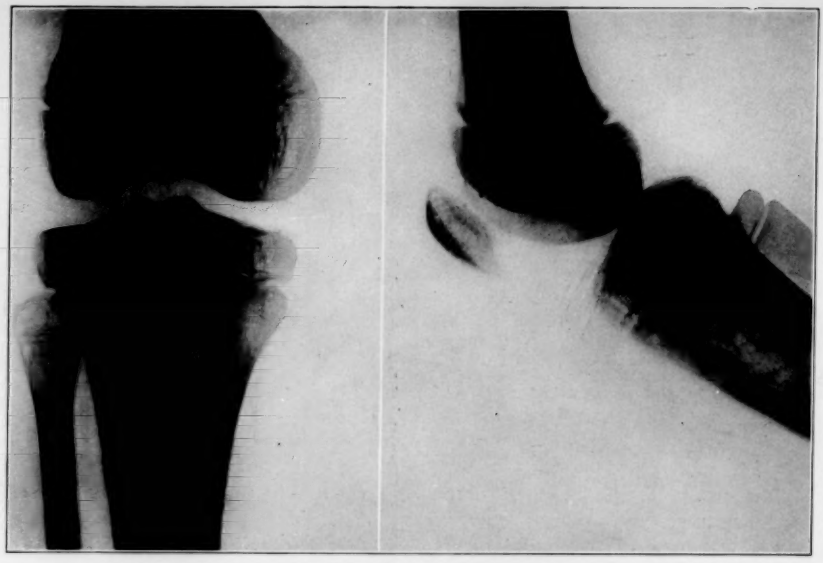

FIG. 3

Site of lesion three years later, after curettage and filling of defect with cancellous bone.

CONCLUSIONS

Certain conclusions may be drawn from this case concerning the role of the epiphyseal plate in solitary bone cysts.

1. Apparently the cysts are usually delimited by the cartilage plate from extension into the epiphysis, but this rule is not infallible, and one must not be guided by this finding alone in arriving at a preoperative diagnosis.

2. A defect in the cartilage plate may not limit growth in the area of the defect unless the peripheral portion of the plate—that adjacent to the cortex—is also destroyed.

3. Curettage and filling the cavity with bone chips, as reported by numerous authors [1–5, 7], arrests the progress of the lesion and results in the cavity being filled with normal-appearing bone. Even when a cavity is packed, so that the bone crosses into the epiphyseal area through a defect in the epiphyseal-cartilage plate, it probably will not arrest normal bone growth.

NOTE: The author wishes to thank Walter Scott, M.D., for permission to use his case in this report.

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ACUTE NON-TUBERCULOUS PSOAS ABSCESS: A CLINICAL ENTITY

Report of Seven Cases *

BY ISADORE ZADEK, M.D., NEW YORK, N. Y.

Of seven cases of acute psoas abscess of non-tuberculous origin reported here, none was the result of direct extension from a pelvic organ, such as an acutely inflamed appendix. None followed a postpartum infection. None was an extension upward, such as cellulitis or lymphangiitis, from an affected lower extremity, or an extension downward, as from empyema.

The diagnosis had not been made in any case prior to the time the patient was seen by the author. All of the patients were operated upon and all recovered.

One patient (F. L., aged twenty-four) had had osteomyelitis of her left tibia in childhood and local heat was still evident over the affected bone, probably the source of her infection. Another had had acute cellulitis about the left knee, which had been drained twice just prior to the development of the psoas abscess. The abscess was not spreading and was under control. The other cases were cryptogenetic.

Numerous isolated cases of this condition have been reported. The earlier cases had not been diagnosed clinically, but were accidental findings at postmortem examinations. In a review of the literature, it is often impossible to discover whether the author is describing an acute abscess or an abscess secondary to Pott's disease; indeed, in the excellent article by Baer, Bennett, and Nachlas, the tuberculous and acute pyogenic abscesses are grouped.

Behrman reported four cases seen at the Queen's Hospital for Children. The original diagnosis was appendicitis in two of these children, arthritis of the hip in one, and Pott's disease in the fourth.

Barney reported fully the case of a patient operated upon by him in 1930 with the mistaken diagnosis of perinephritic abscess.

Mark H. Rogers reported seven cases of psoas abscess which he believed were due to infection and suppuration of the lumbar retroperitoneal glands. One of these was tuberculous; the others were apparently the result of acute infections.

The first clear reference to acute psoas abscess which the author was able to find was a report of two cases by Mynter in 1881. Both abscesses were drained below Poupart's ligament. Both patients recovered.

Long reported several of these cases in 1925, with characteristic histories. The abscesses were large and were readily felt, medial to the anterior superior spine of the ilium, usually just below it.

It seems hardly necessary to point out the signs of psoas abscess. What is necessary is to be aware of the existence of the acute psoas abscess as a clinical entity, and to suspect it in a patient who is acutely or moderately ill, who has fever and pain in a pelvic fossa or in the loin with pain referred to the hip, groin, thigh, or lower back, and whose clinical picture does not indicate a characteristic perinephritic or intra-abdominal lesion.

PHYSICAL EXAMINATION

On examination, we find that the patient's hip is flexed between 90 and 150 degrees. Inflammation of the hip can be readily ruled out if further flexion of the hip is free and painless. At times, there is a tendency for the patient to keep the hip in outward rotation, so that internal rotation may be slightly restricted.

If the patient is able to stand, the affected extremity is kept advanced in relation

* Read at the Annual Meeting of The American Orthopaedic Association, Colorado Springs, Colorado, May 20, 1949.

to the opposite side, with the trunk deviated toward the affected side and the pelvis tilted down on this side, the knee and hip being slightly flexed. The lumbar lordosis may be increased. The trunk is tilted forward, and there is spasm of the sacrospinalis on the opposite side. This muscle is relaxed on the affected side. If the patient bends forward, there is freedom of this motion and the forward flexion is completed in the mid-line, the spasm of the spinal muscles disappearing and thus ruling out spinal involvement.

There is sensitiveness to pressure in the pelvic fossa on the affected side. A mass will be palpable if the abscess is sufficiently large. Otherwise, only a feeling of resistance is encountered. There is absence of spasm and rigidity of the abdominal muscles.

LABORATORY FINDINGS

Laboratory studies show an increase in the white-blood-cell count to 15,000 or 20,000 with 80 per cent. or more of segmented white cells. The sedimentation rate is increased. Roentgenographic examinations of the spine, hip, and pelvis are negative. In only one of these cases was a protrusion of the iliopsoas noted; this was seen laterally in the belly of the psoas. In the other six cases, this finding was not present.

TREATMENT

Treatment consisted in surgical drainage. These patients were operated upon through a MacBurney exposure; the peritoneum was pushed forward by blunt dissection, sponges on clamps being used to prevent perforation of the peritoneum.

Through this exposure, one may investigate both the upper and lower portions of the muscle and institute drainage by inserting two Penrose drains. The drains should be sewed to the skin to prevent their extrusion; they should be shortened after three or four days and removed completely after about ten days. It may be necessary to insert packing into the orifice of the wound. If the drains are left untouched too long, a faecal fistula may develop.

CLINICAL FINDINGS

In all of these patients, the pus was found within the psoas sheath in the substance of the muscle. No evidence of necrotic lymph-node tissue was observed. There was no evidence of old hemorrhage in any case. This is mentioned because it is conceivable that an accumulation of blood in the muscle could act as a culture medium for the development of the abscess.

The psoas is large and of considerable substance. It is the most important flexor of the hip and is used in standing, walking, and sitting. Possibly the normal activity of this muscle makes it more vulnerable to infection. Primary infection of muscle is uncommon.

The seven patients varied in age from nine to thirty years. The right side was affected four times; the left, three times. Four of the patients were males and three were females. The most recent case was seen in 1947, the one before it in 1938.

The infecting organism was *Staphylococcus aureus* in five abscesses. In one it was *Streptococcus haemolyticus*. No growth was obtained from the pus of one abscess. This patient had been receiving penicillin for several days prior to examination. His abscess was large, containing three ounces of pus. His Wassermann reaction was positive.

There was a history of trauma in three cases, sharp pain in the side being experienced while the patient was lifting a heavy object. Two of these patients had active infection elsewhere in the body, which was the source of the abscess.

CASE REPORTS

CASE 1. A. T., a boy, aged eleven years, had been ill for three weeks with severe pain in the left side, but there was no history of injury. He had a high fever. He had been seen by a number of doctors, one of whom insisted that a boy so ill must have acute osteomyelitis.

At operation on March 11, 1927, a small abscess was found in the mid-portion of the psoas muscle; *Staphylococcus aureus* was grown from the pus.

The original hospital record of this case was lost.

CASE 2. D. W., a man, aged thirty, had had sharp pain in the right groin and hip of two weeks' duration. There was no history of injury. Just prior to admission to the hospital, the pain had become intense. The right hip was flexed. There had been no nausea or vomiting. The patient had noticed stiffness of his right thigh and pain when standing or raising the right leg. His temperature at the time of admission was 100.6 degrees, white-blood-cell count 15,000, and polymorphonuclear neutrophils 90 per cent. Urinalysis was negative.

On the day after admission, through an error in diagnosis, an appendectomy was performed. The appendix, however, was normal.

Eight days later, the patient was worse. His temperature varied between 101 and 102 degrees. A diagnosis of tuberculosis of the spine or kidney was entertained.

At examination on September 28, 1934, marked spasm of the iliopsoas was noted. The hip was flexed to 150 degrees. There was sensitiveness in the right pelvic fossa, and a mass was palpable which gave a sensation of deep fluctuation. The white-blood-cell count was 16,400, polymorphonuclear neutrophils 89 per cent. His temperature was 102 degrees.

The abscess was drained on September 29, and contained ten ounces of creamy yellowish-green pus. Culture from the pus showed *Staphylococcus aureus.*

CASE 3. J. O., a girl, aged ten, had had acute pain in the right flank and the right lower abdominal region, radiating to the lower extremity, two weeks previous to examination by the author. The patient was nauseated and had vomited several times. There was no history of injury. Her temperature was 103 degrees and there was frequency of urination. The urine contained 30 to 50 pus cells per high-power field. The blood examination showed 14,600 white blood cells and 79 per cent. polymorphonuclear neutrophils. The diagnosis at the time of admission had been pyelitis.

Examination with the patient out of bed was unsatisfactory, because she could not stand alone. When supported, she tilted forward and kept the right hip flexed. In the supine position, her hip was flexed to 90 degrees. Further flexion (passive) was free. Other motions were free with the exception of extension. There was sensitiveness in the right pelvic fossa and some fullness. Rectal examination showed slight fullness on the right.

At operation, on June 14, 1935, an abscess was found high in the psoas muscle, which contained an ounce of thick pus. Culture from this pus yielded *Staphylococcus aureus.*

CASE 4. R. D., a male, aged fifteen, had experienced cramping pain in the left pelvic region after having lifted a heavy tray, two or three days prior to admission to the hospital. The pain did not radiate. Nausea first appeared the night before admission. He had a headache and felt listless.

Soon after admission, the patient's temperature was 104 degrees. The white-blood-cell count was 13,900, with 83 per cent. polymorphonuclear neutrophils. *Staphylococcus aureus* was cultured from the blood.

No diagnosis was made, although tuberculosis, typhoid fever, and incipient pneumonia were considered.

The patient was very ill. When taken out of bed for examination, he was able to stand only by holding the bed for support. When lying in bed, the left hip was flexed to 140 degrees. Further flexion of the hip was not limited. There was local resistance in the left pelvic fossa, but no mass could be palpated. He complained of pain when pressure was applied in this region.

At operation, a small amount of free fluid was found in the psoas sheath, without local abscess formation. The wound was drained. Culture from this fluid showed *Staphylococcus aureus.*

CASE 5. F. L., a woman, aged twenty-four, complained of pain in the upper portion of the right thigh and in the inguinal region. Three or four weeks previously, while lifting a rug, she had felt a strain and had experienced pain in the proximal portion of her right thigh. This pain had persisted, and she had chills and fever each night. Flexion of the extremity on this side relieved her pain.

The white-blood-cell count was 18,300, with 80 per cent. polymorphonuclear neutrophils.

In childhood, the patient had had osteomyelitis of the left tibia, for which operation had been performed.

When examined, on January 17, 1936, the patient's general condition was good. She walked with a marked limp on the right side, the right hip and right knee being flexed. As she stood on the fore part of her right foot, the trunk was deviated to the right; when she bent forward, the deviation disappeared. The pelvis was tilted downward on the right. There was no spasm of the sacrospinalis on the right, but marked spasm was present on the left. When the patient bent forward, this spasm disappeared. The lumbar lordosis was slightly increased.

As she lay in bed, in the supine position, the right hip was flexed to 125 degrees. Further flexion of the

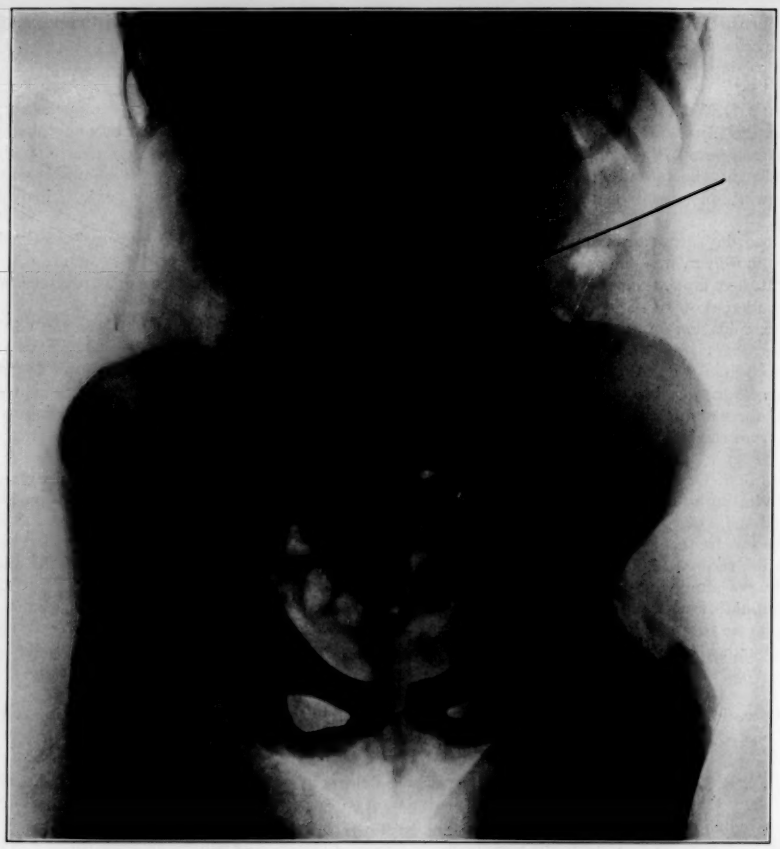

FIG. 1

B.G. Roentgenogram showing bulging of the iliopsoas on the left side. (Although films were made in each of these cases, this is the only one that showed the bulging.)

hip was not limited or painful. External rotation of the right hip produced relief of pain, whereas internal rotation caused increased pain and limitation of motion. On the left side, both internal and external rotation were free. There was infiltration in the right pelvic fossa and marked pain, not present on the left. With the hip flexed, there was no limitation of motion of the right knee. Over the left tibia was a nine-inch scar, adherent to the underlying bone; the local temperature about the scar was increased.

At operation, on January 20, 1936, an abscess was found in the lower portion of the psoas muscle. It contained several ounces of pus, culture from which yielded *Staphylococcus aureus*.

CASE 6. B. G., a girl, aged nine, had been having a high fever. She had an infection in the soft parts about the left knee, which had been drained twice. She had had a gastro-intestinal upset and had vomited. A limp was present on the left side. Roentgenograms of the left knee had indicated to the surgeon who operated upon her that she had an infection in the upper portion of her left tibia, although the clinical signs did not substantiate this. She had been ill for three weeks before being seen by the author.

The child was examined on June 15, 1938. With assistance, she took a few steps, holding the left knee flexed at 165 degrees and with the left hip flexed. There was spasm of the iliopsoas on the left, and the left hip was flexed to 130 degrees. There was resistance in the left pelvic fossa, but no spasm of the abdominal muscles.

The wounds of two recent operations about the left knee were granulating nicely, and there was no

evidence of any pus being dammed back. The white-blood-cell count was 20,000 with 80 per cent. polymorphonuclear neutrophils. There was no history of trauma.

Roentgenograms on June 13 showed a small area of rarefaction in the upper portion of the tibia, which was a cartilage inclusion and of no significance. This had been interpreted by her surgeon as an abscess.

At operation on June 28, 1938, a small abscess, containing one-half ounce of pus, was found at the lower pole of the psoas muscle (Fig. 1). Culture from this pus yielded *Streptococcus haemolyticus*.

CASE 7. J. C., a man, aged twenty-seven, was treated for a back sprain, which had occurred three weeks before he was seen by the author. After lifting a heavy piece of furniture, he had felt transient pain in the back on the right side, which increased materially two or three days later. He began to limp eight or nine days after the injury. His back had been strapped with adhesive tape. He had worked irregularly after the injury, but had not been able to do a full day's work.

When examined, on February 18, 1947, he walked with a marked limp on the right side. The right hip was flexed to 135 degrees.

There was sensitiveness in the right lower quadrant, and a feeling of resistance was encountered which suggested deep fluctuation. There was no sensitiveness over any part of his spine. All motions in the right hip, with the exception of extension, were free. The patient was given penicillin and his temperature, which had been 101 degrees, returned to normal. When the penicillin was discontinued, his temperature promptly returned to 101. On February 24 his white-blood-cell count was 16,300, with 67 per cent. polymorphonuclear neutrophils. The Wassermann reaction was + + + +.

At operation, on February 25, an abscess was found in the mid-portion of the psoas muscle, and three ounces of pus were evacuated. Culture was negative. In the midst of this abscess, a large mass of fibrin was encountered.

CONCLUSIONS

This small series of cases call attention to a clinical entity with which many members of the medical profession, including competent orthopaedic surgeons and general surgeons, are not familiar.

These cases require early surgical intervention, in contrast to the treatment of psoas abscesses of tuberculous origin.

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DISCUSSION

DR. I. WILLIAM NACHLAS, BALTIMORE, MARYLAND: The paper just presented does more than add case reports about a condition that often goes undiagnosed. It emphasizes the occurrence of psoas abscesses which are not only non-spinal, but also non-tuberculous in origin. The need for such emphasis is indicated by the fact that in the current book, *Standard Nomenclature of Diseases*, used in hospitals for indexing diagnoses, no recognition is given to such a lesion. In fact, when I tried to find some of our cases of acute psoas abscess preparatory to discussing this paper, under the heading of psoas abscess was written: "Diagnosis—Tuberculosis of the Vertebra". No allowance was made for the disease entity "acute psoas abscess".

In light of the presentation of Dr. Zadek and the cases quoted by him from the literature, this omission should be corrected. Furthermore, this clinical entity should be brought to the attention of members of the medical profession, because most of these cases are seen by the general practitioner or the general surgeon long before they reach the orthopaedic surgeon, if they reach him at all.

Dr. Zadek has carefully avoided any conclusions regarding the mode of onset of the abscess. Although some of us have attributed the condition to a breakdown of retroperitoneal lymph nodes, he indicates that in his cases there was no evidence of necrosis of the lymph tissue. We have been able to demonstrate lymphadenitis with degeneration in several patients. With regard to diagnosis, in addition to noting the signs that Dr. Zadek has just enumerated, we have occasionally done preoperative aspiration of the abscess. This is quite a safe procedure. When pus is produced, it helps us not only to substantiate the diagnosis, but also to determine the nature and type of organism. In this day of selective antibiosis, such information is of real value.

The operative approach that Dr. Zadek has described is, in my opinion, much better than the one that we described, chiefly because it allows much better drainage.

DR. ZADEK (closing): As I have stated, there are many isolated case reports, particularly in the French literature. The condition is referred to as "psoitis", so that possibly the cases would be indexed under that name.

The early case reports were in German, as postmortems are much more readily obtained in Germany than in this country. The condition was an accidental finding at autopsy examination, had not previously been diagnosed clinically, and was apparently the cause of death in some of these cases.

I wonder about aspiration of these abscesses. Some of them are small, and I would rather operate upon the patient and explore the retroperitoneal area than to insert a needle, for fear of perforating the peritoneum. With a large abscess, I think there would be no difficulty, but with a small abscess, this would be a hazardous procedure.

ARM-TRACTION APPARATUS

BY GUSTAV BOHSTEDT, PH.D., MADISON, WISCONSIN

A simple, but effective, apparatus has been devised for relieving the discomfort of a patient whose arm is in traction. This apparatus enables the patient in bed to be elevated from a horizontal to an inclined or sitting position, while the arm traction is kept in alignment at all times. An occasional change from the horizontal to an inclined position is obviously an aid in the prevention of hypostatic pneumonia, especially in aged patients.

FIG. 1

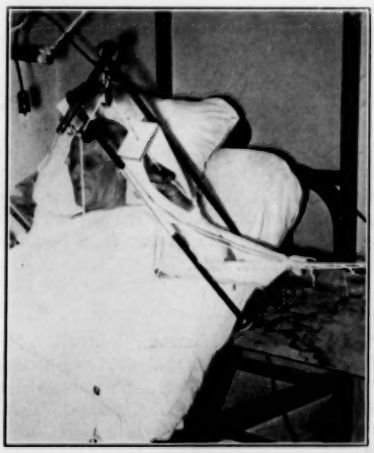

FIG. 2

Fig. 1: The essential parts of the arm-traction apparatus, which may be attached to a hospital bed.
Fig. 2: The patient experiences considerable relief from being able to assume an elevated position.

The apparatus consists of a board, clamped crosswise about mid-way on the adjustable head-end part of a hospital bed, to which are attached standards for lateral and vertical traction. An anchor standard is attached to the opposite side of the bed (Figs. 1 and 2). The weight of most patients is sufficient to prevent them from being pulled sideways in bed by the lateral traction, even while they are sitting at the usual angle. Nevertheless, a counter pull from the anchor may be needed at times.

The apparatus may, with slight adjustments, be used for traction on either side.

NOTE: This apparatus was prepared with the assistance of James S. Hipple, Mechanician of the Wisconsin General Hospital, Madison.

GIANT-CELL TUMOR CONFINED TO THE GREATER TROCHANTER

A Case Report

BY MARCUS J. STEWART, M.D., AND OTIS E. JAMES, JR., M.D., MEMPHIS, TENNESSEE

From Campbell Clinic and University of Tennessee College of Medicine, Department of Surgery, Memphis

Destructive lesions of the greater trochanter present an interesting and stimulating problem in differential diagnosis, because of the similarity in roentgenographic findings produced by lesions of widely divergent pathological origin. A review of the literature has revealed no instance of a giant-cell tumor entirely confined to the greater trochanter, although a number of cases have been reported of giant-cell tumors of the proximal portion of the femur, some of which have involved the greater trochanter. Henderson reported three such cases in 1928; Peabody reported one case in 1921; Herendeen and Lewis reported one case in 1930. Coley stated that in two series of giant-cell tumors of the femur, totaling 176 cases, only twenty-two were located in the proximal end of the femur. Copeland reported four cases with involvement of the greater trochanter in a series of twenty-nine cases located in the femur.

Probably the most common destructive isolated lesion of the greater trochanter is tuberculosis, although the frequency of tuberculous involvement of the greater trochanter, compared with that of the remainder of the skeleton, is relatively rare. Peabody found six cases with involvement of the greater trochanter in a series of 3,062 cases of tuberculosis of bone and joints seen at Massachusetts General Hospital. Wassersug, in 1940, reported eighteen cases of tuberculosis of the greater trochanter in a series of 1,017 cases with skeletal involvement, an incidence of 1.8 per cent.

CASE REPORT

In August 1947, a fourteen-year-old girl was admitted to Campbell Clinic, complaining of a dull, aching pain in the region of the right hip of eight months' duration. There had been a decided limp and progressive restriction of motion for the preceding three months. The symptoms were aggravated by activity and improved by rest, but there had been no night pain or night cries. Recently some pain had been noted in the right knee, particularly in association with excessive activity. There was an unknown amount of weight loss, but no history of fever, exposure to tuberculosis, or trauma.

Physical examination showed a well developed, well nourished girl of fourteen years, of average stature and apparently in good health. The patient stood with a rather marked list of the body to the right; otherwise examination of the spine and pelvis was negative. The hips were of normal contour; there was no evidence of swelling, increase in local temperature, or hyperaemia. There was no fluctuation, but there was marked tenderness to pressure over the right greater trochanter and over the posterior aspect of the right hip joint. Motion in the hip was limited to about 60 per cent. of normal; further movement was restricted by pain. The lower extremities were of equal length, but there was one and one-quarter inches of atrophy of the right thigh. The left hip revealed no abnormalities. Neurological findings in the lower extremities were normal.

A complete blood count disclosed no abnormalities. The serum Kline and Wassermann reactions were negative. The sedimentation rate according to the Cutler technique was 31 millimeters in one hour and 32.5 millimeters in two hours. An intradermal skin test for tuberculosis was positive at a dilution of 0.0001. Roentgenograms of the pelvis and hips revealed a destructive lesion of the greater trochanter on the right; a circumscribed area of osteoporosis extended down to the superior portion of the neck of the femur. The entire greater trochanter was involved, with fragmentation of the superolateral portion of the cortex and slightly increased calcification along the medial side. There was no relative increase in decalcification of the remaining portions of the shaft, neck, or head of the femur (Fig. 1). Roentgenographic examination of the chest was negative.

Serosanguineous fluid was aspirated from the area of the greater trochanter. Culture for tuberculosis on Petragnani medium was negative after six weeks. Biopsy was refused. The patient was advised to remain in bed for at least two months.

She returned on October 15, 1947, stating that she had been in bed continually except for bathroom privileges, and was completely free of pain and soreness in the hip. She still walked with a definite limp and a list of the body to the right. There was a marked decrease in the amount of tenderness and soft-tissue reaction about the hip, and a substantial increase in the range of motion of the joint. Laboratory studies showed no essential changes. Roentgenograms of the right hip revealed the same circumscribed area of involvement noted previously, but with some increase of calcification around the periphery, particularly on the superior portion of the trochanter (Fig. 2). There appeared to be no invasion of the shaft or neck of the femur, but there was slight periosteal proliferation along the lateral portion of the proximal metaphyseal region of the femur. Again biopsy was refused. The patient was instructed to continue with the conservative regimen.

She returned on January 7, 1948, complaining of an exacerbation of pain and disability in the right hip. There was marked restriction of motion and considerable tenderness to pressure over the greater trochanter,

FIG. 1

Initial lateral and anteroposterior views showing erosion of lateral cortex.

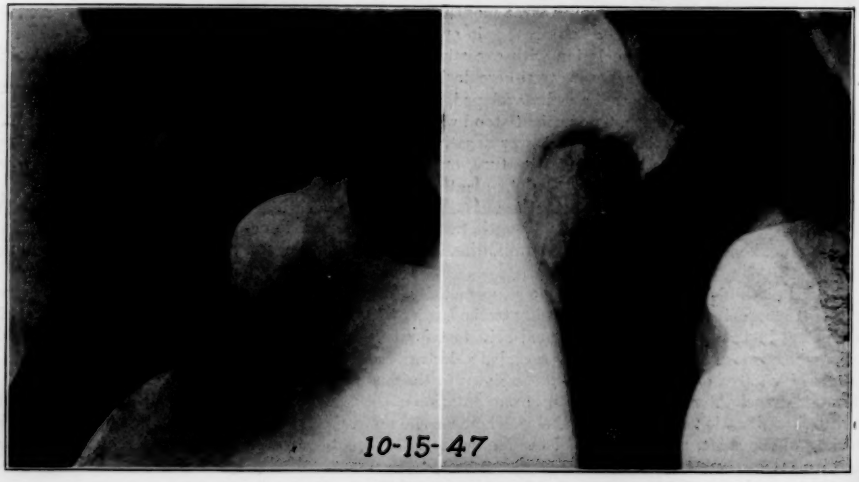

FIG. 2

Two months later, roentgenograms show healing of lateral cortex with proliferative growth and periosteal reaction.

but no evidence of increased local temperature, hyperaemia, or fluctuation. There was no evidence of involvement elsewhere in the body. Roentgenograms showed a further extension of the pathological process, with suggestion of spread into the superolateral portion of the neck of the femur, although a sharp line of demarcation remained between the normal and pathological bone. Reactive new bone was present around the periphery of the entire trochanter, with a "fuzzy" type of proliferation along the medial and superior portions, and generalized increase in density. There was some increase in the amount of periosteal proliferation along the lateral proximal portion of the shaft of the femur. These roentgenograms suggested a rather rapidly growing pathological process, compatible with neoplasm (Fig. 3). The possibility of an osteogenic sarcoma was discussed and biopsy was agreed upon. Regardless of the pathological findings, it was deemed advisable that the greater trochanter should be resected.

On January 8, under general anaesthesia, the greater trochanter was removed. The soft tissue adjacent to the lesion was oedematous and congested. The greater trochanter was replaced by an expansile, localized fibrous-tissue growth, measuring about 8 by 5 by 4 centimeters, with no evidence of invasion of the adjacent bone or soft tissue (Fig. 4). No true lining membrane or capsule was noted, but there was a sharp demarcation between the tumor and the normal bone of the femoral neck. The entire cavity was thoroughly curetted; material for biopsy was obtained from the superior portion of the neck of the femur, which formed the floor of the cavity. There was no hemorrhage. The gluteal muscles were reattached to the distal portion of the trochanteric region. Microscopic examination of the tissue revealed a giant-cell tumor (Figs. 5-A and 5-B). Biopsy from the neck of the femur showed normal bone. The patient's postoperative course was uneventful, and at four weeks she was allowed to begin partial weight-bearing with crutches.

Two and one-half months after operation, the patient had no symptoms and there was a complete range of active motion in the hip. She was seen at intervals of two months. At the last examination, on February 17, 1950, she was completely free of symptoms. Roentgenograms showed partial regeneration of the greater trochanter with con-

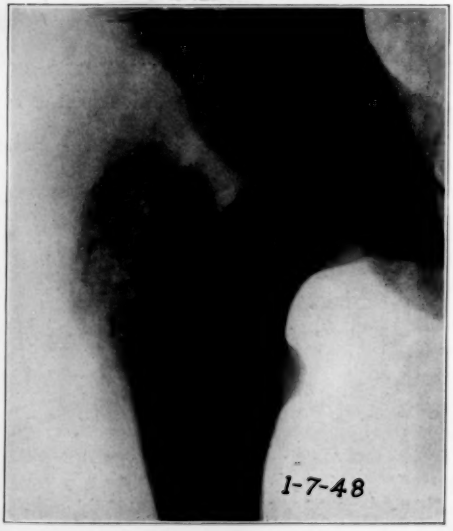

FIG. 3

Rapid extension of tumor with neoplastic characteristics.

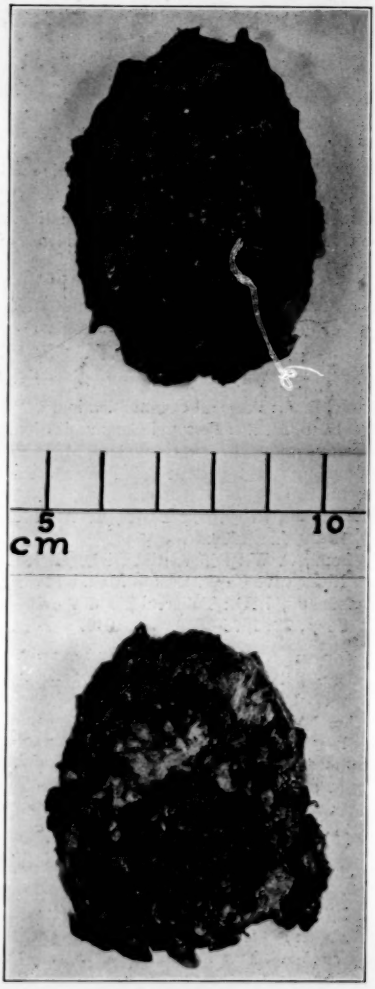

FIG. 4

Gross specimen.

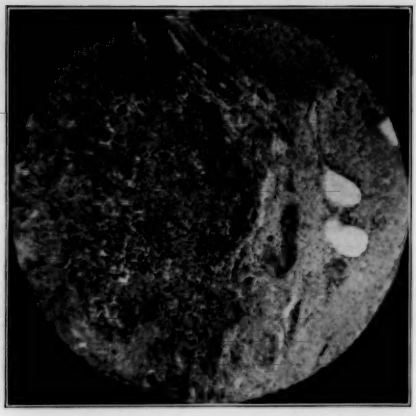

FIG. 5-A

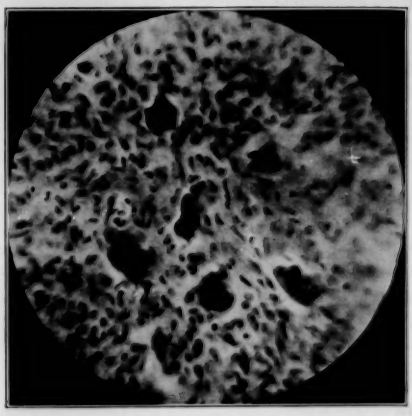

FIG. 5-B

Fig. 5-A: Low-power microscopic section (× 83) of the tumor with adjacent normal tissue.
Fig. 5-B: High-power microscopic section (× 357) of tumor.

siderable well organized new-bone formation, and density in the superior portion of the neck adjacent to the trochanteric area. There was no evidence of osteoporosis in the head, neck, or acetabulum.

In this case the signs, symptoms, and findings were in keeping with a diagnosis of giant-cell tumor, although the initial roentgenograms and physical findings were compatible with tuberculosis.

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A PROSTHESIS ATTACHMENT FOR SHORT AMPUTATION STUMPS BELOW THE KNEE

BY ANTHONY ARZIMANOGLOU, M.D., ATHENS, GREECE

From the Cripples Department of the Ministry of War, Athens

The principal difficulties encountered in dealing with short stumps below the knee (two to three inches long) are, first, that the stump invariably slips out of the artificial limb when the amputee kneels or ascends stairs; and, second, that it is practically impossible to extend the artificial leg with the help of only the anterior portion of such a short stump.

With a view to overcoming these difficulties, the author has conceived the device described here (Fig. 1), which has already been applied successfully.

A leather socket was made to fit the short stump. To the peripheral end of this socket was fixed a metal rod, extending to the upper tarsal region of the artificial leg; an inverted cup was screwed to the lower end of this rod. A coil spring was placed in the cup, with the lower end of the spring resting on the artificial limb, slightly above the level of the tarsal region.

The whole system is fitted into a conventional artificial limb. (It may be significant that the prostheses constructed by the State Artificial Limb Factory of Greece are wooden and, therefore, quite heavy.)

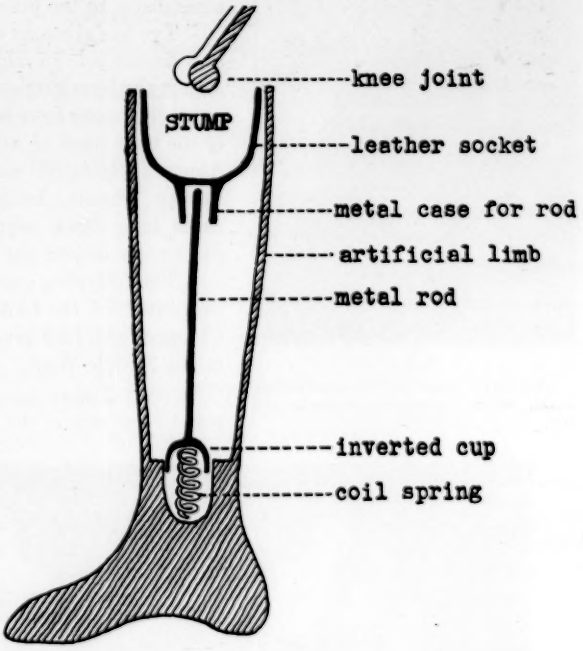

FIG. 1

Sectional view of prosthesis, into which attachment has been incorporated.

By means of this device, the following results have been achieved:

1. The firm, comfortable grip provided by the socket and the steady upward pressure of the coil spring prevent the stump from slipping out of the prosthesis.

2. The effective length of the stump is thereby increased, so that the amputee can easily extend the artificial limb.

The author has used this device on amputees, already wearing a conventional prosthesis, who complained that they could neither sit nor walk. They were all highly satisfied with the new type of artificial limb, and stated that, not only could they climb stairs and sit without any slipping of the stump, but also they were able to extend the prosthesis as far as they liked. They further declared that, due to the constant pressure maintained upon the stump, they experienced an agreeable feeling of walking and standing "on their own feet".

AINHUM

BY JAMES K. STACK, M.D., CHICAGO, ILLINOIS

Ainhum is described as a chronic disease of unknown etiology, usually affecting the fifth toe, less commonly the fourth, and, rarely, both. It is characterized by the spontaneous formation of a constricting ring, appearing first on the plantar surface of the base of the toe and finally producing complete encirclement. As a result of the gradual strangulation, there is produced a collagenic degeneration of the soft tissues, endarteritis, and a rarefying osteitis of the bone distal to the point of constriction.

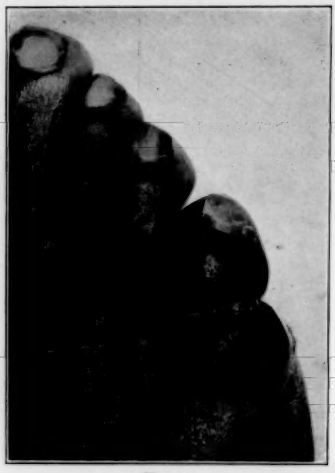

FIG. 1

The dorsal aspect of the constricting band, which completely encircles the toe.

Tye has given an excellent review of the literature on this subject. In addition to reporting the first case seen in the New England area, he stated: "The greatest number of cases have been reported among the Negroes of the west coast of Africa, the West Indies and South America. Isolated cases have been reported from Europe, Russia, Istanbul and India, and about 45 cases have been seen in the United States . . ." principally among the southern negroes.

The following case is of interest in that the condition involved the foot of a negro, born and raised in Chicago, who had never traveled beyond the environs of the Middle West.

C. W., a negro male, thirty-two years old, weighing 140 pounds, was seen in the Orthopaedic Clinic at Cook County

FIG. 2

Roentgenographic appearance of the toes of both feet. Note the soft-tissue shadow of the constriction, and the atrophy that has been produced in the phalanges of the fifth toe.

Hospital in January 1949. His principal complaint was pain in the right fifth toe, present for about three months, but increasing in severity. His attention had been called to a slight deformity of the toe some time prior to the onset of pain, and he had noted that the toe was not so mobile as its fellow on the opposite side. He was admitted to the Hospital, where general physical examination and blood studies were found to be non-contributory. The color of that portion of the toe distal to the constriction was essentially the same as that of the other toes, and no variation in temperature was noted. Active movement was not possible; passive movement produced pain, as did pressure at the point of constriction.

The toe was amputated at the metatarsophalangeal level and, in addition, an exostectomy of the lateral and plantar surfaces of the fifth metatarsal head was done. The wound healed by first intention and the patient was discharged from the Hospital on the ninth postoperative day. His recovery was uneventful and he returned to his work as a kitchen helper.

Microscopic studies of the soft tissue and the phalanges were similar to those described by Spinzig in 1939.

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A CAST SPREADER

BY JOHN E. STEWART, M.D., MERIDEN, CONNECTICUT

The author has devised a simple and effective cast spreader which can be constructed from a valve lifter used by automobile mechanics. This valve lifter can be purchased from an automobile supply store for a small sum and requires only the addition of two metal

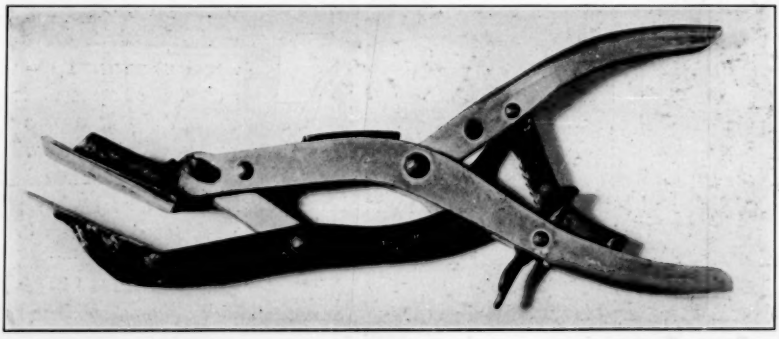

FIG. 1

plates, brazed into position (Fig. 1), to convert it into a cast spreader. In addition to its low cost, it offers the following advantages: (1) A good leverage system is provided in proportion to the small size of the instrument; and (2) a ratchet holds the blades apart after the instrument has spread the cast, thus allowing the operator to cut underlying sheet wadding.

INTERINNOMINO-ABDOMINAL (HINDQUARTER) AMPUTATION

BY ROBERT A. ROBINSON, M.D., ROCHESTER, NEW YORK

From the Division of Orthopaedics, Department of Surgery, University of Rochester School of Medicine and Strong Memorial Hospital

Interinnomino-abdominal amputations are being performed more frequently, as means have been developed to combat shock and reduce the high operative mortality first associated with this procedure[1]. This paper describes a device which materially increases the ease and speed of the surgical procedure, without compromising the gentle handling of tissues necessary for success in this type of surgery. Decreasing the operating time and eliminating the turning of the patient may contribute, other factors being equal, to the avoidance of surgical shock and reduction of the possibility of wound infection in interinnomino-abdominal amputation.

In 1946, Sorondo and Ferré, of the *Instituto de Cirugía de la Provincia de Buenos Aires*, presented their method of interinnomino-abdominal amputation to the Inter-American Congress of Surgery. They had carried out this operation on four patients. The patient lay on the unaffected side during the procedure. The position was maintained by four boards or metal plates. The diseased limb was raised by a cord attached to the ankle. Two teams operated, so that the work through the abdominal and gluteal incisions could be carried out simultaneously, thus reducing the operating time and making it unnecessary to turn the patient when half-way through the operation.

The basic idea of this method of operation was used during the last three interinnomino-abdominal amputations at the Strong Memorial Hospital, and resulted in a reduction of the average operating time (from beginning of the operation to removal of the

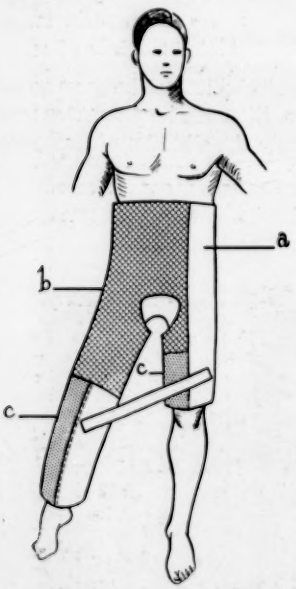

FIG. 1

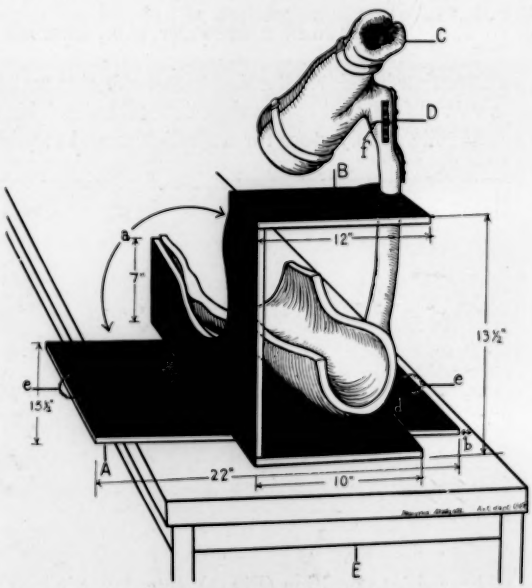

FIG. 2

Fig. 1: Sectioning of body spica. Section *a* was preserved intact with crossbar. Section *b* was discarded. Sections *c* were preserved. Sections *a* and *c* were taped along the edges and sections *c* were fitted with straps to facilitate their attachment to section *a* during surgery.

Fig. 2: Diagram of device.

specimen) from 213 to 128 minutes, or approximately 40 per cent. These operations were all performed under the direct supervision of J. J. Morton, so that the time factor in all eight cases is comparable.

The basic idea was modified in this way: Several days prior to operation the first of the three patients was placed in a well fitting one and one-half leg-hip-body spica. This spica was cut as shown in Figure 1, removed from the patient, and dried thoroughly. The modified spica was attached to a U-shaped wooden frame (Fig. 2,*B*), connected to a wooden baseboard (*A*) by a stout hinge. The hinge allowed the U-shaped frame, into which the modified spica had been fitted, to be tilted through angle *a*, so that the patient could lie supine during induction of anaesthesia (Fig. 5) and be tilted up on the unaffected side (Fig. 3) during the operative procedure. The baseboard (Fig. 2,*A*) was equipped with two rope handles (*e*), which allowed the center of gravity of the whole device to be placed over the center of the operating table (*E*) by moving it back and forth through transit (*b*). This mobility is necessary, since the center of gravity of the patient moves one foot as the patient is swung through arc *a*, after induction of the anaesthesia and just prior to preparation of the operative site.

The center of gravity of the device lies to one side of the hinge, so that it is possible

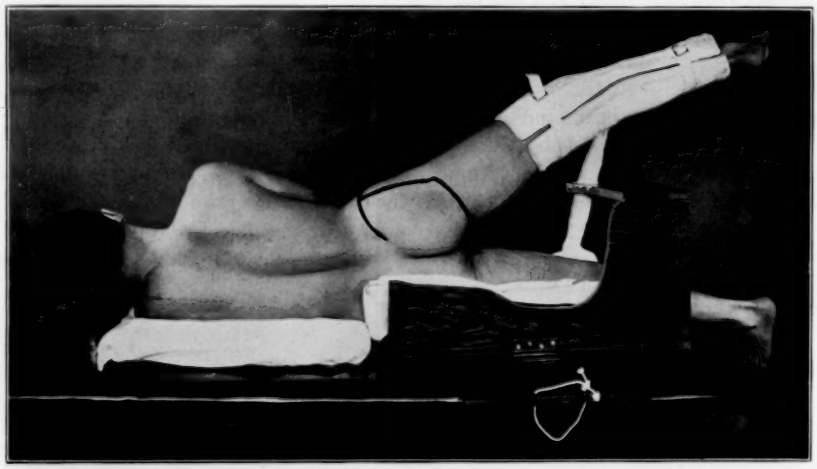

FIG. 3

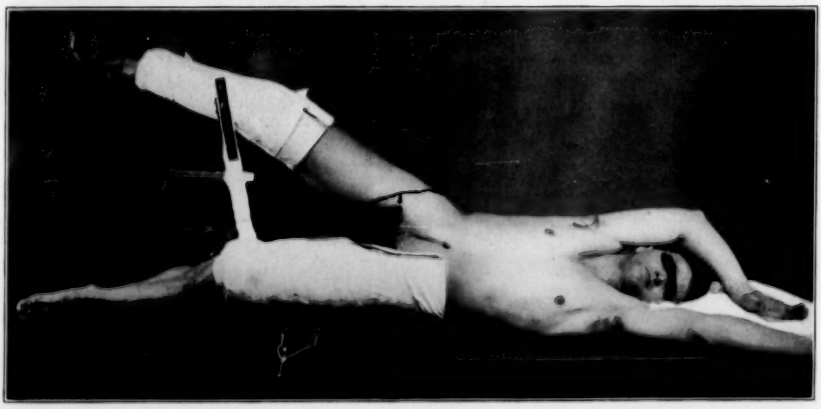

FIG. 4

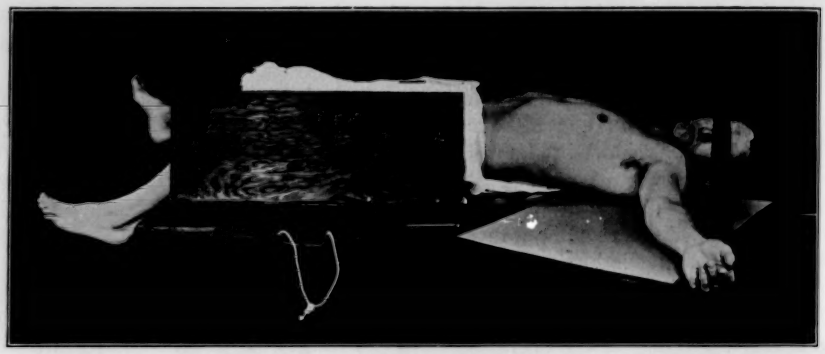

FIG. 5

to tilt the patient by placing a block (*d*) between the U-shaped frame (*B*) and the baseboard (*A*). This tilting (Fig. 4) permits easier access for the surgeon working through the abdominal approach, and does not hinder the surgeon working through the gluteal incision. The U-shaped frame and the baseboard are both strapped to the operating table (*E*), after the patient has been placed in the final position for surgery (Fig. 3).

The arm on the healthy side is in practically the same position, both when the patient is supine and when he is tilted on his side; approach for the necessary intravenous fluids is, therefore, available during induction of the anaesthesia (Fig. 5).

After the interinnomino-abdominal amputation has been completed, section *C* (Fig. 2) of the modified spica is removed from the field with the diseased hindquarter which it contains. This is accomplished by removing the distal four screws in plate *D*. The crossbar, having been sectioned prior to operation at point *f*, separates upon removal of the screws without the creation of dust. Care is taken, when draping the patient, to leave access to plate *D* outside the operative field. Following removal of section *C* with the amputated hindquarter, a sheet is placed over the device, distal to the operative site, and the wound is closed.

The diseased side in the last three patients being the same, the device made specifically for the first patient was used in each case. The general design allows enough latitude so that, with one right-sided and one left-sided device, provision is made for almost any adult patient.

Figures 3 and 4 show the lines of incision used. The broken line across the pubis illustrates an extension of the incision occasionally used to expose the region of the symphysis pubis.

NOTE: Grateful acknowledgment is made to J. J. Morton, M.D., Professor of Surgery, University of Rochester School of Medicine and Dentistry, for testing and approving this device. For the diagrams the author is indebted to N. C. Jacobs of the Art Department, and for the photographic illustrations to M. C. Orser of the Photography Department, School of Medicine and Dentistry, University of Rochester.

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SPOT ORTHOROENTGENOGRAPHY

A Method for Measuring the Length of the Bones of the Lower Extremity

BY LOUIS A. GOLDSTEIN, M.D., AND FRANK DREISINGER, R.T., ROCHESTER, NEW YORK

From the Department of Surgery, Division of Orthopaedic Surgery, and the Department of Radiology, University of Rochester School of Medicine and Dentistry

A method for the accurate measurement of length of the lower extremity in the growing child is of importance in orthopaedic practice. It is frequently necessary to record any discrepancy in the length of an individual bone and to check this, as well as the total limb length, by measurement at regular intervals. Knowledge of the rate of growth of the individual bones and the gains in total limb length is especially important if epiphyseal arrest is to be performed [1].

In 1946, Green, Wyatt, and Anderson reported a method of measuring limb length by orthoroentgenograms. The method employed three separate exposures for the lower extremity, centered successively over the hips, knees, and ankle joints and made on one long film,—fourteen inches wide and any desired length up to forty inches. A target-to-film distance of six feet was used. This technique required a tunnel for the long cassette (fourteen inches by forty-four inches), into which had been incorporated two sliding metal shields. These workers pointed out the greater accuracy of orthoroentgenograms, as compared with teleoroentgenograms.

Warren White, in his technique of estimating limb-length inequality, suggested including an exposure of the left wrist and hand on the same film, for determination of bone maturity.

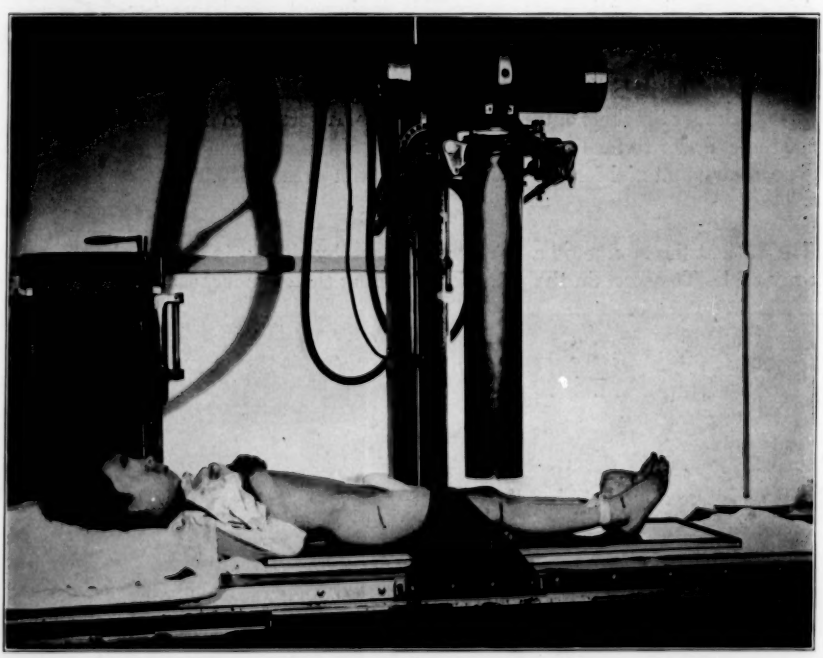

FIG. 1

Shows patient in position for spot orthoroentgenogram.

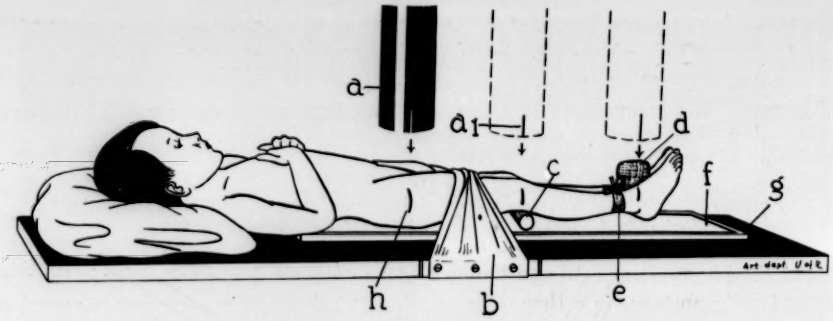

FIG. 2

Diagram of Fig. 1.

a: Brass cone is centered over hip joint. Dotted lines illustrate cone centered successively over knee and ankle joints for respective exposures.
a_1: Line on cone used for centering cone over joint.
b: Compression band.
c: One-inch cylindrical wood block.
d: Pad between medial malleoli.
e: Two-inch bandage binding ankles together.
f: Cassette, fourteen by thirty-six inches, on top of x-ray table.
g: X-ray table.
h: Pencil mark on skin at joint for centering cone.

In considering the adoption of orthoroentgenography for limb-length measurement, the authors found that the principle could be employed with the facilities existing in the X-ray Department. The modification of Green's technique, to be described, is referred to as "spot orthoroentgenography" and has been in use in our Department since early 1947. The technique is simple; the measurements are accurate and have proved to be very satisfactory.

Any modern diagnostic roentgenographic equipment may be used with the addition of a cassette, fourteen inches by thirty-six inches, and a brass cylinder, twenty-six inches long and four and one-half inches in diameter (Fig. 1). One-sixteenth-inch round brass stock is a standard item at all retail stores selling metal. The cylinder is attached to a cone base with four brackets of the right-angle type. A vertical mark is painted on opposite sides of the cylinder to facilitate visual centering of the roentgenographic tube. The cost of the necessary material for the cylinder should not exceed $10.00.

TECHNIQUE

The patient lies supine on a cassette, fourteen by thirty-six inches, placed on top of the x-ray table. To ascertain the point for centering the cylinder, each joint is flexed and

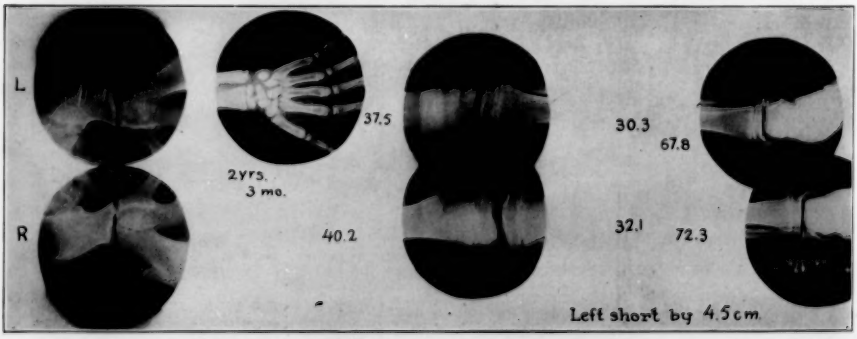

FIG. 3

Spot orthoroentgenogram on film, fourteen by thirty-six inches. Left hand and wrist are included for determination of bone age.

a wax pencil mark is placed on the lateral aspect of each joint. To prevent movement during the examination, the following immobilizing devices are used (Fig. 2):

1. A pad is placed between the medial malleoli of the ankles, and the legs are tied closely together, just above the malleoli, with a length of two-inch gauze bandage.

2. A cylinder of wood, one inch in diameter, is placed under the knees to provide firm support and to maintain the knees equidistant from the film.

3. A compression band is applied over the thighs. Occasionally, with restless children, a second compression band is required across the legs.

With the patient in the position outlined, the mark on the brass cylinder is aligned with the mark over each joint and the six exposures are made rapidly. Roentgenograms of the left wrist and hand are then taken on the same film for determination of bone age. Due to the coning effect of the cylinder, it is unnecessary to block off any part of the film with lead.

Technical Factors

With screens of average speed and at a distance of forty inches, the following technical factors are used:

	Milliampere-Seconds	*Kilovolt-Peak*
Ankle	10	45
Knee	10	52
Hip	20	60
Hand	5	40

Target-film distances of forty inches and seventy-two inches have been compared by this method. The forty-inch target-film distance simplifies the technique and the findings are as accurate as with the longer distance, provided each joint has been well centered. At a distance of forty inches, it is considerably easier to level and center the x-ray tube. "Spot orthoroentgenograms" of the right lower extremity of a six-year-old child, with forty-inch and seventy-two-inch target-film distance taken on the same film, resulted in exactly equal measurements of 29.2 centimeters for the femur and 23.1 centimeters for the tibia. In addition, the film was cut vertically and the two halves were superimposed; this resulted in exact overlay of the bone ends and of the wax-pencil markings used for measurements.

Sources of Error

It is important that each joint be positioned in the center of the projected circle. If the hip joint is shown at the extreme top of the upper circle and the ankle joint at the bottom of the lower circle, an error of 1.3 per cent. is possible.

Errors in measurement may be introduced by the film itself:

1. The average processing shrinkage of films, thirty-six inches long, is 0.25 per cent.

2. Humidity expansion per 10 per cent. of relative humidity is 0.11 per cent.

3. Thermal expansion per 10 per cent. Fahrenheit is 0.06 per cent. (For each 10 per cent. of the Fahrenheit scale, expansion due to heat will be 0.06 per cent.)

The possible errors due to film characteristics are significant only when temperature and humidity are subject to extreme variation, and can be eliminated by the use of a calibrated-marker guide.

Advantages

1. Existing equipment may be used.

2. The brass cylinder is inexpensive to construct and may be used for lateral roentgenograms of the femoral neck, the paranasal sinuses, or for spot roentgenograms of any part of the body.

3. A target-film distance of forty inches is as accurate as the greater distances that have been used by others, and is more convenient.

4. Individual exposures eliminate the distortion due to limb-length inequality.

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1. GREEN, W. T., and ANDERSON, MARGARET: Experiences with Epiphyseal Arrest in Correcting Discrepancies in Length of the Lower Extremities in Infantile Paralysis. A Method of Predicting the Effect. J. Bone and Joint Surg., **29**: 659–675, July 1947.
2. GREEN, W. T.; WYATT, G. M.; and ANDERSON, MARGARET: Orthoroentgenography as a Method of Measuring the Bones of the Lower Extremities. J. Bone and Joint Surg., **28**: 60–65, Jan. 1946.
3. WHITE, J. W.: Personal communication.

THE CONVEX SADDLE FRAME

AN AID IN SPINE SURGERY *

BY HOWARD B. SHORBE, M.D., AND EARL D. MCBRIDE, M.D., OKLAHOMA CITY, OKLAHOMA

The convex saddle frame is a convenient, safe, and simple support for the prone body of the patient during operations on the spine. It is particularly valuable in cervical and lumbosacral surgery. Special tables, pillows, and sandbags may be eliminated.

The prone position with flexion offers many advantages in providing better visualization, and facilitates the steps involved in spine operations. The padded bars of the frame leave the abdomen free from pressure, thus removing an objection stressed by those who have advocated the lateral flexed position.

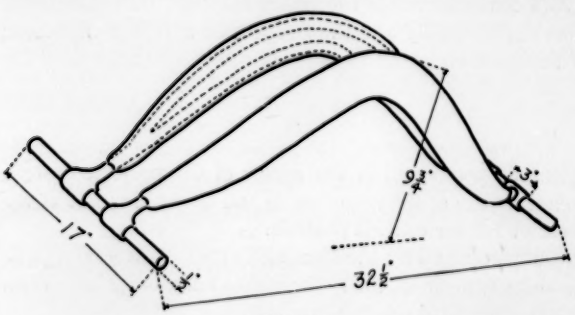

FIG. 1
Diagram of frame.

The frame described was developed at the Bone and Joint Hospital, and has been used in its present form for more than three years. It has purposely been kept as simple as possible.

The frame is constructed of five-eighths-inch tubular steel and may be built easily by a bracemaker. There are two elevated double bars of convex contour, in parabolic relationship to two longitudinal base bars. The distance to the vertex is nine and three-quarters inches. The length of the base is thirty-two and one-half inches. The convex double bars can be made adaptable to varying widths of the pelvis by means of telescoping bars at each end, provided with Adams setscrews. The inner member of each convex double bar is attached at a slightly lower level to make a sloping, resting base, about four or five inches wide when padded like a saddle (Fig. 1). Each

* Exhibited at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 24–29, 1948.

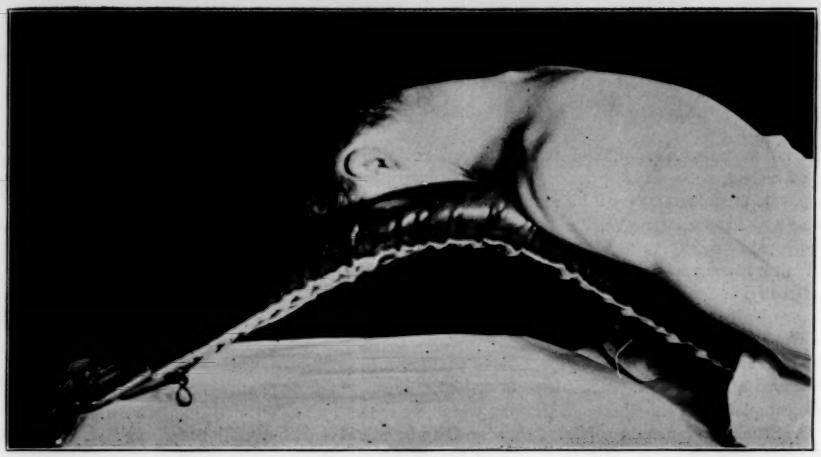

FIG. 2

Photograph shows patient placed for a cervical operation.

convex double bar is well padded with approximately one inch of felt, covered with soft sponge rubber. The surface covering is a plastic fabric, laced on the undersurface of the bars so that it may be conveniently removed if necessary.

The advantages of the frame are as follows:

1. In lumbar operations it provides a desirable convex position of the spine for exposure of the interlaminal spaces.

2. In cervical operations it also provides a favorable contour and firm stability of the neck, with the face resting between the bars. The convex bars are brought together until the patient's face fits comfortably.

3. The frame will fit on any operating table.

4. The frame is easily transportable.

5. Abdominal pressure is eliminated. Venous engorgement is minimal in the spinal canal, and hemorrhage is diminished.

6. The anaesthetic may be given more easily, either in cervical or in lumbar surgery. Respiration is not impaired, and both arms are available for venoclysis.

With the patient prone on this frame, the interlaminal spaces are favorably expanded, and in most instances it is unnecessary to remove any of the lamina in excision of a herniated intervertebral disc. Figure 2 shows a patient placed for a cervical operation. Placement for a lumbar or lumbosacral operation has been illustrated previously [1].

At the completion of the operation, the frame and patient are gently rolled over on the side, and the patient is then straightened on his back on the carrier. Properly applied "lock" type of grafts will not become displaced with this manoeuvre.

1. MCBRIDE, E. D.: A Mortised Transfacet Bone Block for Lumbosacral Fusion. J. Bone and Joint Surg., **31-A**: 385–393, Apr. 1949.

WALTER GOODLOE STUCK

1905–1950

Dr. Walter Goodloe Stuck of San Antonio, Texas, died unexpectedly on March 21, 1950. Walter had been extremely active in his private work and in many phases of work connected with local and national orthopaedic organizations until his illness became known to him in January 1950. Suddenly confronted with such an appalling catastrophe, Walter calmly wrote the various groups and resigned from the duties which he cherished so deeply.

Walter Stuck was born at Jonesboro, Arkansas, on January 19, 1905. He received his early education in Jonesboro High School and attended Hendrix College of Conway, Arkansas, for two years. He transferred to Emory University, Georgia, where he received his Bachelor-of-Science degree in 1926. He was graduated from Washington University School of Medicine, St. Louis, in 1929. After serving an internship in surgery at the University of Michigan, he spent three years as a fellow in orthopaedic surgery at the Mayo Clinic. He received a Master-of-Science degree in orthopaedic surgery from the University of Minnesota in 1934. At the completion of this thorough training period, he entered private practice in San Antonio.

Dr. Stuck was a member of The American Orthopaedic Association, The American Academy of Orthopaedic Surgeons, and The Texas Orthopaedic Association. He was also a member of Sigma Xi.

He made many valuable contributions to the orthopaedic literature. He was extremely active in the field of fracture therapy, being personally responsible for many points of improvement in the technique for open reduction and internal fixation. In 1947 he published, in conjunction with Dr. Charles S. Venable, a textbook entitled, "The Internal Fixation of Fractures". The importance of this contribution can be appreciated by quoting a phrase from the foreword written by Dr. Ralph Ghormley as follows: "This volume covers the whole story of internal fixation from its earliest use to its present status".

At the time of his death he had finished his work as Chairman of the Committee on Scientific Investigation for The American Academy of Orthopaedic Surgeons. During the previous year he had conducted the study required for the presentation of the first Kappa Delta Award.

Dr. Stuck is survived by his wife, Mrs. Eleanor Buck Stuck, and by two daughters, Eleanor Ann Stuck and Margaret Elizabeth Stuck.

His untimely death represents a tremendous loss to orthopaedic surgery.

LETTER TO THE EDITOR

I have just received the October number of *The Journal of Bone and Joint Surgery*, containing the article, "Surgical Approach to the Vertebral Body", by Dr. Arthur A. Michele and Dr. Frederick J. Krueger. In this work they state: "Needle biopsy of the thoracolumbar vertebrae is not only a blind and dangerous procedure, but frequently yields unreliable and inadequate material for diagnosis".

Dr. Ottolenghi, Dr. Schajowicz, and I published in *The Journal of the American Medical Association* (Vol. 136, p. 376, 1948) a special method for aspiration biopsy of the vertebral bodies, which we have employed in over 300 cases. During my most recent visit to the United States, I discussed this procedure in many hospitals, and was pleased to realize that some outstanding orthopaedic surgeons are employing the method with success.

In the October 1942 issue of *The Journal* (Vol. 24, p. 952) was published a review of our book on aspiration biopsy in the diagnosis of osseous lesions. A chapter in the book is devoted to the aspiration of the vertebral bodies as a diagnostic aid.

We doubt that the statement of Michele and Krueger about needle biopsy is correct.

Dr. José Valls
Maipú 757
Buenos Aires, Argentina

December 23, 1949

News Notes

THE AMERICAN ORTHOPAEDIC ASSOCIATION

The Sixty-third Annual Meeting of The American Orthopaedic Association will be held at the Cavalier, Virginia Beach, Virginia, on May 23, 24, 25, and 26, 1950, under the presidency of Dr. Robert W. Johnson.

A Clinical Day program will be provided in Baltimore on Monday, May 22. The morning session will be conducted at the Johns Hopkins Hospital from nine until twelve o'clock. Luncheon will be served at the Children's Hospital School, and an afternoon session will be held there. Dr. I. William Nachlas is in charge of the scientific program and Dr. George O. Eaton is in charge of the transportation in Baltimore.

The tentative program of the Meeting, as submitted by the Program Committee, is as follows:

Tuesday, May 23

Noon: Executive Session

Afternoon Session

Diamond-Shaped Iliac Grafts for Non-Union of the Tibia.
Harry C. Blair, M.D., Portland, Oregon.

Marrow Nailing in Recent Long-Bone Fractures and in Cases of Delayed and Non-Union.
Colonel Oral B. Bolibaugh, M.C., San Francisco, California;
Michael J. Hitchko, M.D., San Francisco, California (by invitation).

A Preliminary Report on Subtrochanteric Osteotomy and Splint Fixation of Certain Hip-Joint Disabilities.
David Bosworth, M.D., New York, N. Y.;
Mather Cleveland, M.D., New York, N. Y.;
A. Della Pietra, M.D., New York, N. Y. (by invitation).

Gradual Subluxation of the Cervical Spine.
John G. Kuhns, M.D., Boston, Massachusetts.

Wednesday, May 24

Morning Session

The Surgical Management of Chronic Osteomyelitis by Saucerization, Primary Closure, and Antibiotic Control. Preliminary Report on Use of Aureomycin.
Joseph Buchman, M.D., New York, N. Y.;
John E. Blair, Ph.D., New York, N. Y. (by invitation).

Anatomy and Physiology of Club Feet with Suggestions for Their Correction.
Steele F. Stewart, M.D., Honolulu, T. H.

Scoliosis: Its Treatment by Directed Growth Control.
I. William Nachlas, M.D., Baltimore, Maryland.

Wedge Excision of Congenital Vertebral Defects in Infancy.
Philip Wiles, F.R.C.S., London, England (by invitation).

Further Considerations on Arthroplasty of the Hip.
M. N. Smith-Petersen, M.D., Boston, Massachusetts.

Thursday, May 25

Morning Session

Collison Metallic Femoral Head.
Leonard T. Peterson, M.D., Washington, D. C.

Experimental and Clinical Use of Oxidized Cellulose in Prevention of Excess Bone Formation.
Frank E. Stinchfield, M.D., New York, N. Y.

The Viability of Various Types of Bone Grafts as Determined by Radio-Active Phosphorus.
J. Albert Key, M.D., St. Louis, Missouri;
Richard T. Odell, M.D., St. Louis, Missouri (by invitation);
C. Barber Mueller, M.D., St. Louis, Missouri (by invitation).

Presidential Address.
Robert W. Johnson, Jr., M.D., Baltimore, Maryland.

Friday, May 26

Morning Session

Subastragalar Fusion under Five Years of Age.
David Grice, M.D., Boston, Massachusetts (by invitation).

Action of Muscles in Health and Disease.
Verne T. Inman, M.D., San Francisco, California;
LeRoy C. Abbott, M.D., San Francisco, California;
John B. deC. M. Saunders, M.B., San Francisco, California (by invitation).
Vitamin-Resistant Rickets.
H. R. McCarroll, M.D., St. Louis, Missouri;
H. E. Pedersen, M.D., St. Louis, Missouri (by invitation).
The General-Adaptation Syndrome and the Diseases of Adaptation.
Hans Selye, M.D., Montreal, Quebec (by invitation).

Noon: Final Executive Session

ARTHUR SIMS COMMONWEALTH TRAVELLING PROFESSORSHIP

Sir Reginald Watson-Jones has been a visitor to this continent in a new and unique capacity. He landed at New York from the Queen Mary accompanied by Lady Watson-Jones on February 14 en route to Canada.

He has visited the medical schools of Canada in discharge of his responsibilities as the Sims Professor of the Royal College of Surgeons of England.

This Chair was founded by the benefaction of Sir Arthur Sims of New Zealand, for the purpose of facilitating the exchange of surgical knowledge between Great Britain and the nations of the British Commonwealth. Sir Reginald is the third annual incumbent of the Chair and the first to visit Canada. His itinerary across Canada was arranged by the Royal College of Physicians and Surgeons of Canada.

On the completion of his visit to Canada, he continues his tour to Singapore, Australia, New Zealand, and South Africa.

While in New York, Sir Reginald and Lady Watson-Jones attended the annual dinner of The American Academy of Orthopaedic Surgeons, and Sir Reginald conducted a course in fracture treatment for the New York and Brooklyn Committee on Fractures and Other Trauma of the American College of Surgeons, which had been arranged by the Chairman, Dr. Preston A. Wade.

On February 17, 1950, recognition was made of the sixtieth birthday of Dr. Bedrich Frejka, Professor of Orthopaedic Surgery and Chief of the Orthopaedic Clinic of Masaryk University, Brno. As a representative of Czechoslovakia, Professor Frejka has visited many national and international surgical gatherings, and has been honored with membership in many orthopaedic societies. He is a Corresponding Member of The American Orthopaedic Association and an Honorary Member of The American Academy of Orthopaedic Surgeons.

The Roswell Park medal has been awarded by the **Buffalo Surgical Society** to Dr. Dallas B. Phemister. Dr. Phemister gave the Roswell Park lecture at a dinner meeting held at the Hotel Statler, Buffalo, on March 30. His subject was "Changes in the Treatment of Infections of Bones and Joints since the Introduction of Antimicrobial Drugs".

The newly elected officers of the **Sociedad Cubana de Ortopedia y Traumatologia** for the year 1950–1951 are as follows: President, Dr. Pedro Sánchez Toledo; Vice-President, Dr. Harry Romney; Secretary, Dr. Luis Iglesias de la Torre; Assistant Secretary, Dr. José Sampedro; Treasurer, Dr. José Pérez Lorié; and Assistant Treasurer, Dr. Alberto Barba Inclán.

The **Fourth Annual Amputee Conference** will be held at the Kessler Institute for Rehabilitation on April 20, 21, and 22, 1950. An interesting program has been prepared. Additional information may be obtained from Miss Signe Brunnstrom, Director of Professional Education, Kessler Institute for Rehabilitation, Pleasant Valley Way, West Orange, New Jersey.

"Fractures: An Introduction" is the title of a sound motion picture in full color, prepared for the American College of Surgeons under the supervision of Dr. Harrison L. McLaughlin. The film was produced by Eddie Albert Productions, Inc., under a grant from the Johnson & Johnson Research Foundation.

This introductory film has been designed to illustrate the pathology and repair, the basic principles of treatment, and certain standard technical procedures. Subsequent films will deal in more detail with various phases of the subject, and the more specialized methods of fracture treatment.

The purpose of the film is to improve the teaching of fracture treatment. It will be sent free of charge to any hospital in the United States desirous of using it for instructional purposes in the teaching of undergraduate and graduate nurses, interns, residents, and other personnel, or to any doctor who may wish to use it in any hospital with which he is associated, or for the purpose of group discussion at a meeting of an

orthopaedic or medical society. To obtain the film for such use, application should be made to Orthopedic Products Division, Johnson & Johnson, New Brunswick, New Jersey, giving the date for which it is desired and the address of the person to whom the film should be sent.

AMERICAN SOCIETY FOR SURGERY OF THE HAND

The American Society for Surgery of the Hand held its Fifth Annual Meeting at Hosack Hall in the New York Academy of Medicine, February 10, 1950, Dr. Thomas W. Stevenson presiding.

Dr. Julian M. Bruner of Des Moines, Iowa, discussed "Safety Factors in Tourniquet Hemostatis". Although he had been unable to find clinical evidence to show just how long a pneumatic tourniquet could safely be kept on the upper extremity, he believed the effects of prolonged application were puffiness of the fingers, stiffness of the finger joints, color changes, subjective numbness, and objective weakness of the forearm muscles. He recommended shortening the time of use by proper planning of the operation, rapid dissection, and removal of the tourniquet before closure of the wound. The tourniquet should be applied smoothly and over a wide area, and should be inflated quickly to a pressure of from 270 to 300 millimeters of mercury in adults and 250 millimeters in children. When the tourniquet is removed, firm pressure by a compression bandage should be applied and allowed to remain five minutes before an attempt is made to ligate the bleeding points.

In a discussion, Dr. Mason stated that he used the blood-pressure cuff inflated to 280 millimeters; after release of the tourniquet and ligation of the bleeding points he reapplied the tourniquet, the dressings being in place before its final removal.

Three speakers discussed "Tumors of the Hand". Dr. Michael L. Mason, of Chicago, reviewed the types of tumors in the hand. Of all tumors seen, 12 per cent. were malignant and most of them followed irradiation. Arsenical dermatitis was an occasional cause. Epidermoid cysts were found less frequently than xanthomata; sebaceous cysts occurred infrequently, and always on the dorsum of the hand. Synovial cysts were commonly found at the distal finger joints. Among unusual tumors seen were arteriovenous angiomata and glomus tumors. Melanomata are uncommon, but important in that the subungual type should be distinguished. Metastatic lesions are rare in the hand, but have been reported from the breast, prostate, adrenals, testis, kidney, colon, and bronchus. Among bone tumors, enchondroma is the most common and is often diagnosed only when a spontaneous fracture has occurred.

Dr. Henry C. Marble of Boston discussed hemangiomata, stating that they are commonly misdiagnosed and inadequately treated. He stressed the need for thorough and careful excision.

Dr. Arthur P. Stout of New York City reported a series of 1,346 soft-tissue tumors in the hand, 10 per cent. of which were malignant. The ganglion comprised almost one-third of the cases. The giant-cell tumor or xanthoma is the type next commonly seen. Dr. Stout stated that pigmented tumors are often found to be malignant, but, because this series consisted only of those tumors which had been excised and examined pathologically, the number of malignant growths did not reflect the true incidence in all pigmented tumors.

Dr. Sterling Bunnell of San Francisco presented a motion picture, illustrating the use of spring and elastic-controlled splints to bring the hand into the functioning position and prevent stiffness. He pointed out the importance of the wrist joint, as being the key to deforming factors in the hand.

Dr. Joseph H. Boyes of Los Angeles described the surgical anatomy of the motor branch of the ulnar nerve in the palm. He reported several cases of nerve repair at various levels and the rate of regeneration, determined by the time required for recovery of voluntary motion of the first interosseous. He described a method of rerouting the nerve to shorten its course around the hook of the hamate bone.

Dr. Erik Moberg of Sweden described brachial-plexis block with xylocain, stating that the toxicity is approximately the same as that of procaine, but its anaesthetic effects are two to four times as great. In his experience, with the use of ten cubic centimeters of 2 per cent. xylocain solution with epinephrin, the total dose indicated was approximately half of that necessary with procaine. He found, in comparing two series, that the side effects were similar, but nausea was less frequent when xylocain was used.

Dr. Harry Shapiro, Professor of Anthropology at Columbia University, in a very interesting paper, reviewed the theories and evidence of the origin of man; and showed how the hand is a generalized primitive pattern, inherited intact by the reptiles and continuing basically unaltered in that branch giving rise to the mammals.

Dr. Emanuel Kaplan of New York City discussed the embryological development of the extensor apparatus of the fingers and its close relation to the flexor mechanism. He discussed the attachments of the extensor apparatus at the various levels in the fingers, and their relation to the axes of rotation of these same joints. A model hand, showing the various motions of the combined flexor and extensor mechanisms, was displayed.

Dr. Arthur J. Barsky of New York City discussed congenital anomalies of the hand. He reviewed some of the theories of etiology and stated that genetic factors are most important. He recommended early operation to restore function and to allow the hand to develop as a grasping organ. The paper was discussed by Dr. Jerome Webster and Dr. Sterling Bunnell, who agreed with the recommendation for early operation, but mentioned the difficulties presented by scar tissue, which may later cause contractures and must be relieved.

Dr. William H. Frackelton of Milwaukee illustrated the importance of arthrodeses of joints to improve function of the hand, and described methods which he had found useful in contractures of the first cleft and treatment of spastic paralysis. He stressed the importance of position, when the thumb is stabilized, and described a simplified procedure for inserting an iliac-bone graft in the first cleft. He also described the many advantages of skin grafts taken from the antecubital area, where a rather large graft can be obtained, closure being facilitated by flexing the elbow.

Dr. Raymond M. Curtis of Baltimore reported on an experimental study of the tensile strength of tendon repair, and discussed the role of paratenon in the tensile strength of repaired Achilles tendons in rabbits.

Dr. Vernon Luck of Los Angeles showed a motion picture depicting Dupuytren's contracture, and discussed its treatment by subcutaneous fasciotomy, a refinement of the technique described many years ago by Adams. Dr. Luck brought out the danger points in this treatment,—namely, the possibility of damage to the digital nerves. He recommended that fasciotomy be confined to those cases with linear contracting bands in the palm. Cases involving the fascial bands in the fingers are better cared for by excision under direct vision.

On February 11, a clinical session was held at Presbyterian Hospital. Cases were demonstrated illustrating primary tendon repairs, opponens transplants, and reconstruction for median and ulnar palsy. Interesting congenital anomalies were presented by Dr. Jerome Webster and Dr. Arthur Barsky.

The annual business meeting was held at the University Club on February 10. New members elected were Dr. Emanuel B. Kaplan, New York City; Dr. Robert McCormack, Milwaukee, Wisconsin; Dr. Radford C. Tanzer, Hanover, New Hampshire; and Dr. S. M. Dupertuis, Pittsburgh, Pennsylvania.

President for the coming year is Dr. Condict W. Cutler, Jr., of New York City, and President-Elect is Dr. Michael S. Mason of Chicago.

Joseph H. Boyes, M.D.,
Secretary-Treasurer

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Seventeenth Annual Convention of The American Academy of Orthopaedic Surgeons was held at the Waldorf-Astoria, New York, February 11 to 16, 1950, under the presidency of Dr. Mather Cleveland. The Convention was the largest in the history of the Academy; the total registration was over 2,500.

The Audio-Visual Program under the chairmanship of Dr. Frank Stinchfield was well arranged and attracted large audiences.

The Instructional Courses under the chairmanship of Dr. Charles N. Pease were well attended. There were forty courses given by a faculty of fifty-two instructors. The Instructional Course Dinner was held on Monday evening. The "Information Please" Program was both instructive and entertaining. The Starlight Room was filled to capacity.

The Scientific Program was arranged by the Program Committee, of which Dr. Joseph S. Barr was Chairman. The Scientific Program was presented on Monday afternoon, Tuesday, Wednesday, and Thursday forenoon, as follows:

MONDAY, FEBRUARY 13

Afternoon Session

End Results in the Treatment of 100 Fractures of the Femur by Means of Diamond-Shaped Medullary Nail.
Dana M. Street, M.D., Memphis, Tennessee.
Discussion: F. H. Vom Saal, M.D., New York, N. Y.;
Denman C. Hucherson, M.D., Houston, Texas.

TUESDAY, FEBRUARY 14

Morning Session

Vascular Epiphyseal Changes in Congenital Dislocation of the Hip.
William K. Massie, M.D., New York, N. Y. (by invitation).

Late Results in Legg-Perthes Disease.
Eugene R. Mindell, M.D., Chicago, Illinois (by invitation);
Mary S. Sherman, M.D., Chicago, Illinois.
Discussion: Leo S. Lucas, M.D., Portland, Oregon;
Clarence H. Heyman, M.D., Cleveland, Ohio.

Presidential Address.
Mather Cleveland, M.D., New York, N. Y.

Club-Foot—An Embryologic Study of Associated Muscle Abnormalities.
Charles O. Bechtol, M.D., Oakland, California;
Harlan W. Mossman, Ph.D., Madison, Wisconsin (by invitation).
Discussion: Carl E. Badgley, M.D., Ann Arbor, Michigan;
George J. Garceau, M.D., Indianapolis, Indiana.

Possible Clinical Manifestations of Congenital Neurofibromatosis.
H. Relton McCarroll, M.D., St. Louis, Missouri.
Discussion: John R. Cobb, M.D., New York, N. Y.;
William T. Green, M.D., Boston, Massachusetts.

Arthrodesis of the Hip for Instability and Pain in Poliomyelitis.
Halford Hallock, M.D., New York, N. Y.
Discussion: Robert W. Johnson, Jr., M.D., Baltimore, Maryland;
Leo Mayer, M.D., New York, N. Y.

Sympathetic Ganglionectomy in the Treatment of Discrepancies in Leg Length Due to Poliomyelitis.
John A. Reidy, M.D., Boston, Massachusetts;
Thomas F. Broderick, Jr., M.D., Boston, Massachusetts (by invitation);
Joseph S. Barr, M.D., Boston, Massachusetts.
Discussion: R. I. Harris, M.B., Toronto, Canada;
Charles W. Peabody, M.D., Detroit, Michigan.

The Campbell Bone Block: An End-Result Study.
Alvin J. Ingram, M.D., Memphis, Tennessee;
John M. Hundley, M.D., Little Rock, Arkansas (by invitation).
Discussion: Brandon Carrell, M.D., Dallas, Texas;
John Royal Moore, M.D., Philadelphia, Pennsylvania.

The Medical Care Program of the National Foundation for Infantile Paralysis.
Hart E. Van Riper, M.D., New York, N. Y. (by invitation).
Question period opened by H. Relton McCarroll, M.D., St. Louis, Missouri;
John C. McCauley, Jr., M.D., New York, N. Y.

The Juvenile Amputee.
George T. Aitken, M.D., Grand Rapids, Michigan;
Charles H. Frantz, M.D., Grand Rapids, Michigan.
Discussion: Atha Thomas, M.D., Denver, Colorado;
Jerome Lawrence, M.D., New York, N. Y. (by invitation).

WEDNESDAY, FEBRUARY 15

Morning Session

Osteogenesis Produced in Rabbit Muscle by Injecting Bone Extracts.
Joel Hartley, M.D., New York, N. Y.;
Stanley S. Tanz, M.D., Hazelton, Pennsylvania (by invitation).

The Proliferative Response of Joints to Trauma.
J. Vernon Luck, M.D., Los Angeles, California.
Discussion (two papers): Stephen Hudack, M.D., New York, N. Y. (by invitation);
Alfred R. Shands, Jr., M.D., Wilmington, Delaware.

The Use of Muscle Relaxants as an Aid in the Diagnosis and Therapy of Acute Low-Back Disorders.
Edward B. Schlesinger, M.D., New York, N. Y. (by invitation);
Frank E. Stinchfield, M.D., New York, N. Y.
Discussion: Arthur Steindler, M.D., Iowa City, Iowa;
Alonzo J. Neufeld, M.D., Los Angeles, California.

Results of Selective Amputation for Osteogenic Sarcoma.
Albert B. Ferguson, M.D., Boston, Massachusetts.
Discussion: Louis G. Howard, M.D., Boston, Massachusetts;
Mary S. Sherman, M.D., Chicago, Illinois.

Flexor-Tendon Grafts in the Fingers and Thumb: An Evaluation of End Results.
Joseph H. Boyes, M.D., Los Angeles, California (by invitation).
Discussion: Sterling Bunnell, M.D., San Francisco, California;
Walter C. Graham, M.D., Santa Barbara, California.

Afternoon Session

Further Experience in the Management of Osteitis Condensans Ilii.
Frank L. Shipp, M.D., Boston, Massachusetts (by invitation);
G. E. Haggart, M.D., Boston, Massachusetts.

Marie-Strümpell Arthritis: Follow-up Study of X-ray, Physical, and Orthopaedic Therapy.
Lenox D. Baker, M.D., Durham, North Carolina;
Walter A. Hoyt, Jr., M.D., Durham, North Carolina (by invitation);
Ralph W. Coonrad, M.D., Durham, North Carolina (by invitation).
Discussion (two papers): Philip D. Wilson, M.D., New York, N. Y.;
Harry C. Blair, M.D., Portland, Oregon.

Degenerative Changes in the Musculotendinous Cuff of the Shoulder in Various Age Groups.
Anthony F. DePalma, M.D., Philadelphia, Pennsylvania.
Discussion: H. F. Moseley, M.D., Montreal, Canada (by invitation);
Charles O. Bechtol, M.D., Oakland, California.

Tenotomy in Spastic Paraplegia.
Leonard T. Peterson, M.D., Washington, D. C.
Discussion: Arthur S. Abramson, M.D., White Plains, New York (by invitation);
Harold A. Sofield, M.D., Chicago, Illinois.

THURSDAY, FEBRUARY 16

Morning Session

Sling Procedure for Correction of Splay Foot, Primus Varus, and Hallux Valgus Deformities.
Robert J. Joplin, M.D., Boston, Massachusetts.
Discussion: Earl D. McBride, M.D., Oklahoma City, Oklahoma;
H. Page Mauck, M.D., Richmond, Virginia.

Treatment of Major Ligament Tears About the Knee.
Don H. O'Donoghue, M.D., Oklahoma City, Oklahoma.
Discussion: David M. Bosworth, M.D., New York, N. Y.;
T. B. Quigley, M.D., Boston, Massachusetts (by invitation).

Dislocation of the Hip Complicated by Fracture of the Shaft of the Femur on the Same Side.
Ernst Dehne, Lt. Col., Medical Corps, Augusta, Georgia;
E. W. Immermann M.D., Chicago, Illinois (by invitation).

Traumatic Dislocation and Fracture-Dislocation of the Hip: A Survey of 204 Cases Covering a Period of Twenty-one Years.
Vernon P. Thompson, M.D., Los Angeles, California;
Herman C. Epstein, M.D., Los Angeles, California (by invitation).
Discussion (two papers): Sam W. Banks, M.D., Chicago, Illinois;
Marshall R. Urist, M.D., Los Angeles, California (by invitation).

The first Executive Session was held at 3:30 P.M. on Monday, February 13. The second Executive Session was held at 11:40 on Thursday, February 16. At the first Executive Session, membership certificates were presented to the new members. Following is a list of the newly elected Fellows:

Harry Alban, M.D., Long Beach, California
Alfons R. Altenberg, M.D., Monroe, Louisiana
Carl Edgar Anderson, M.D., Santa Rosa, California
Thomas McDowell Anderson, M.D., Dallas, Texas
Otto E. Aufranc, M.D., Boston, Massachusetts
Frank A. Barlow, M.D., Bay Pines, Florida
Wilbur W. Bartels, M.D., Lincoln, Nebraska
James E. Bateman, M.D., Toronto, Canada
Marshall Bergen, M.D., Jersey City, New Jersey
Jack S. Blaisdell, M.D., Santa Ana, California
Leslie M. Bodnar, M.D., South Bend, Indiana
Jesse N. Borden, M.D., Baltimore, Maryland
Thomas A. Brady, M.D., Indianapolis, Indiana
Everett C. Bragg, M.D., New York, N. Y.
Bruce J. Brewer, M.D., Milwaukee, Wisconsin
Ronald Mann Buck, M.D., St. Joseph, Missouri
Charles R. Burbacher, M.D., Coral Gables, Florida
Alan Ralph Cantwell, M.D., New York, N. Y.
Oswald R. Carlander, M.D., Camden, New Jersey

Chalmers Rankin Carr, M.D., Oakland, California
Donald J. Caseley, M.D., Indianapolis, Indiana
Sidney Charnas, M.D., Detroit, Michigan
A. Walter Ciani, M.D., Boston, Massachusetts
Reed S. Clegg, M.D., Salt Lake City, Utah
John K. Coker, M.D., Bakersfield, California
Ben Colloff, M.D., San Francisco, California
Clinton L. Compere, M.D., Chicago, Illinois
Walter Andrew Dalmain, M.D., Bristol, Connecticut
Harold E. Davis, M.D., Portland, Oregon
Paul E. Dee, M.D., Rockford, Illinois
Robert H. Denham, Jr., M.D., South Bend, Indiana
Donald Emory Dial, M.D., Cleveland, Ohio
Martin Dobelle, M.D., Pittsfield, Massachusetts
William R. Duncan, M.D., Seattle, Washington
William G. Durnin, M.D., Long Beach, California
Ralph Kenneth Earp, M.D., St. Louis, Missouri
William C. Edwards, M.D., Washington, Pennsylvania
Kurt L. Eichelbaum, M.D., Chicago, Illinois
Russell B. Erickson, M.D., Buffalo, New York
Saul Ira Firtel, M.D., Newark, New Jersey
H. Francis Forsyth, M.D., Winston-Salem, North Carolina
S. Benjamin Fowler, M.D., Nashville, Tennessee
Theodore A. Fox, M.D., Chicago, Illinois
Albert Louis Freedman, M.D., Green Bay, Wisconsin
Frederick G. Gaenslen, M.D., Milwaukee, Wisconsin
Godfred Germansky, M.D., Far Rockaway, New York
Udell Mathews Gessel, M.D., Los Angeles, California
George G. Gill, M.D., Beaumont, Texas
Aaron M. Gold, M.D., Bronx, New York
Everett J. Gordon, M.D., Washington, D. C.
David Stephen Grice, M.D., Cambridge, Massachusetts
Keith Edward Haines, M.D., Camden, New Jersey
John Iredell Hall, M.D., Macon, Georgia
Robert R. Hampton, M.D., Oakland, California
Leonard Harris, M.D., Newark, New Jersey
Charles H. Herndon, M.D., Cleveland, Ohio
T. Wiley Hodges, M.D., Washington, D. C.
George G. Hollins, Jr., M.D., Norfolk, Virginia
Alvin Hulnick, M.D., Staten Island, New York
Charles M. Ihle, M.D., Eau Claire, Wisconsin
Donald T. Imrie, M.D., Vicksburg, Mississippi
Alvin John Ingram, M.D., Memphis, Tennessee
Irwin A. Jaslow, M.D., New Bedford, Massachusetts
Edward H. Juers, M.D., Red Wing, Minnesota
Harry I. Kaell, M.D., Chicago, Illinois
Sidney Keats, M.D., South Orange, New Jersey
Robert P. Keiser, M.D., Coral Gables, Florida
Hampar Kelikian, M.D., Chicago, Illinois
Hewson I. J. Kellam, M.D., Ottawa, Canada
William A. Knapp, M.D., Fort Worth, Texas
Frank E. Kugler, M.D., Cincinnati, Ohio
Herbert A. Laage, M.D., New York, N. Y.
Otto Lehmann, M.D., Long Branch, New Jersey
Edwin Robert Linwood, M.D., Rockville Centre, New York
Frederick C. Lowry, M.D., Austin, Texas
Clarence A. Luckey, M.D., Stockton, California
William B. MacCracken, M.D., Huntington, West Virginia
John G. McNamara, M.D., Brooklyn, New York
Chester C. McReynolds, M.D., Los Angeles, California
Donald J. Magilligan, M.D., Brooklyn, New York
George H. Marcy, M.D., Buffalo, New York

Leo Markin, M.D., Chicago, Illinois
Jack Eldred Maxfield, M.D., Wichita Falls, Texas
Howard A. Mendelsohn, M.D., Beverly Hills, California
James E. Miller, M.D., Madison, Wisconsin
Royston Miller, M.D., Orlando, Florida
William L. Minear, M.D., Hot Springs, New Mexico
Samuel T. Moore, M.D., Oklahoma City, Oklahoma
Vincent D. Moran, M.D., Buffalo, New York
Robert A. Murray, M.D., Temple, Texas
James William Nellen, M.D., Green Bay, Wisconsin
Robert J. Neville, M.D., Hackensack, New Jersey
Robert W. Newman, M.D., Iowa City, Iowa
P. David Nutter, M.D., Lancaster, Pennsylvania
Malvin J. Nydahl, M.D., Minneapolis, Minnesota
John M. Pendy, M.D., Detroit, Michigan
Wendell G. Peterson, M.D., Tacoma, Washington
George S. Phalen, M.D., Cleveland, Ohio
Nicholas Stark Pickard, M.D., Kansas City, Missouri
Ignacio V. Ponseti, M.D., Iowa City, Iowa
R. Beverley Ray, M.D., Memphis, Tennessee
Eugene Edwin Record, M.D., Boston, Massachusetts
Richard E. Reiley, M.D., Minneapolis, Minnesota
William G. Rhorer, M.D., Long Beach, California
Paul L. Rieth, M.D., Emory University, Georgia
Ansgar K. Rodholm, M.D., Corpus Christi, Texas
Sion Clay Rogers, M.D., Madison, Wisconsin
Frederick G. Rosendahl, M.D., Minneapolis, Minnesota
Donald Ross, M.D., Champaign, Illinois
Abraham S. Rothberg, M.D., New York, N. Y.
Lester A. Russin, M.D., Cincinnati, Ohio
Charles B. Rust, M.D., Burlington, Vermont
Joseph Saal, M.D., Brooklyn, New York
Andrew Schildhaus, M.D., Bronx, New York
Philip T. Schlesinger, M.D., Glens Falls, New York
Henry Doeller Severn, M.D., Asheville, North Carolina
Sid John Shafer, M.D., Chicago, Illinois
Fred Shapiro, M.D., Chicago, Illinois
Robert H. Sherry, M.D., Rockville Centre, New York
Faulkner A. Short, M.D., Portland, Oregon
Jarvis M. Smith, M.D., Montclair, New Jersey
Clarence A. Splithoff, M.D., Oakland, California
Leonard J. Stark, M.D., Cincinnati, Ohio
Louis Starr, M.D., Brooklyn, New York
Saul S. Steinbergh, M.D., Pittsburg, California
Joseph R. Stone, M.D., Milwaukee, Wisconsin
Dana Morris Street, M.D., Memphis, Tennessee
Peter W. Sweetser, M.D., New Bedford, Massachusetts
Henry S. Tanner, M.D., Indianapolis, Indiana
Lowell I. Thomas, M.D., Indianapolis, Indiana
Raymond H. Trott, M.D., Providence, Rhode Island
Jacob H. Turkell, M.D., New York, N. Y.
Edmond Uhry, Jr., M.D., New York, N. Y.
Robert E. Van Demark, M.D., Sioux Falls, South Dakota
Stephen Wahl, M.D., New York, N. Y.
Robert F. Warren, M.D., Brooklyn, New York
Jack K. Wickstrom, M.D., New Orleans, Louisiana
Stephen A. Williams, M.D., Corpus Christi, Texas
Philip Willner, M.D., Newark, New Jersey
Milton J. Wilson, M.D., New York, N. Y.
William H. Wright, M.D., Santa Monica, California
Seymour Zaller, M.D., New York, N. Y.
Vincent Zecchino, M.D., Providence, Rhode Island
Frederick N. Zuck, M.D., Rochester, New York

It was announced that the following had been elected to Corresponding Membership:

Wiktor Dega, M.D., Poznan, Poland
Adam Gruca, M.D., Warsaw, Poland
K. E. Kallio, M.D., Helsinki, Finland

The following were elected to Honorary Membership:

Joseph E. Markee, M.D., Durham, North Carolina
John B. deC. M. Saunders, M.B., San Francisco, California

At the second Executive Session the following officers and committeemen were elected:

President: Guy A. Caldwell, M.D., New Orleans, Louisiana
President-Elect: Joseph S. Barr, M.D., Boston, Massachusetts
Vice President: J. Hiram Kite, M.D., Atlanta, Georgia
Secretary: Harold B. Boyd, M.D., Memphis, Tennessee
Treasurer: H. Relton McCarroll, M.D., St. Louis, Missouri
Librarian-Historian: Claude N. Lambert, M.D., Chicago, Illinois
Member of Membership Committee: Jesse T. Nicholson, M.D., Philadelphia, Pennsylvania
Member of Program Committee: George O. Eaton, M.D., Baltimore, Maryland
Member of Committee on Legislation and Medical Economics:
Frederick R. Thompson, M.D., New York, N. Y.
Member of Committee on Scientific Investigation: Donald E. King, M.D., San Francisco, California
Nominees on American Board of Orthopaedic Surgery:
Clarence H. Heyman, Cleveland, Ohio
Leo S. Lucas, M.D., Portland, Oregon
Junior Members of Executive Committee:
George T. Aitken, M.D., Grand Rapids, Michigan
Joseph D. Godfrey, M.D., Buffalo, New York

The presidential medallion was presented to President Mather Cleveland by Past President Myron O. Henry. The gavel was presented to the new President, Dr. Guy A. Caldwell, by the retiring President, Dr. Mather Cleveland.

The Annual Dinner was held on Wednesday evening, at which time the Kappa Delta Award was made. Dr. Marshall R. Urist was the recipient of this award. Other awards were made as follows:

Scientific Exhibits

Class I: For Originality:

1. Peter B. Wright, M.D., Augusta, Georgia: Paget's Disease.
2. Donald S. Miller, M.D., and Leo Markin, M.D., Chicago, Illinois:
   Vascular Complications in Orthopaedic Surgery.
3. William Cooper, M.D., and Philip D. Wilson, Jr., M.D., New York, N. Y.:
   Nine Decades of Operative Orthopaedics at the Hospital for Special Surgery, 1863–1950.

Class II: For Scientific Value:

1. Edgar M. Bick, M.D., and Joseph W. Copel, M.D., New York, N. Y.:
   Osteogeny of Human Vertebrae.
2. Anthony D. DePalma, M.D., and J. B. White, M.D., Philadelphia, Pennsylvania:
   Degenerative Changes of the Musculocutaneous Cuff Noted in the Various Decades.
3. Raphael R. Goldenberg, M.D., Paterson, New Jersey:
   Paget's Disease.

Class III: For Clinical Value:

1. Robert J. Joplin, M.D., Boston, Massachusetts:
   Sling Procedure to Correct "Splay Foot", Hallux Valgus, and Primus Varus Deformities.
2. George T. Aitken, M.D., and Charles H. Frantz, M.D., Grand Rapids, Michigan:
   The Juvenile Amputee.
3. Vernon P. Thompson, M.D., and Herman C. Epstein, M.D., Los Angeles, California:
   Dislocation and Fracture-Dislocation of the Hip.

Gadget Exhibit

1. James A. Dickson and James B. Woodruff, Cleveland, Ohio:
   Coxometer, a Device Used in Arthrodesis of the Hip for Exact Positioning to Procure Ankylosis in Optimum Position for Function.
2. A. R. Shands, Jr., M.D., Wilmington, Delaware:
   New Projector Attachment for Projection of X-ray Films.
3. Charles S. Venable, San Antonio, Texas:
   Impaction Coaptation Bone Plate.

The Eighteenth Annual Convention will be held at the Palmer House, Chicago, Januarv 27 to February 1, 1951, under the presidency of Dr. Guy A. Caldwell.

INTRAMEDULLARY FIXATION*

BY HUGH SMITH, M.D., MEMPHIS, TENNESSEE

In October 1947, the Office of Scientific Research and Development, Surgeon General's Office, authorized a substantial grant through the National Research Council for an extensive clinical investigation of intramedullary fixation of all long bones. Further impetus was given to this line of research when the Fracture Committee of the Academy adopted intramedullary fixation as a project to parallel that of external skeletal fixation.

The project originally was set up as follows:

A. To establish firmly the indications, contra-indications, and limitations of the method.
B. To determine the best method of insertion and extraction of pins.
C. To improve and redesign available surgical instruments and pins.
D. To carry out basic research to answer some of the fundamental questions of fracture healing with intramedullary fixation, particularly its effect on endosteal and periosteal callus.
E. Having obtained a substantial series of cases, to compare this method with previous techniques as to end results.

In 1947, two surgical-instrument houses were commissioned to make the necessary tools. More than eighteen months were consumed in designing and redesigning pins and instruments which were mainly modifications of the ideas of Küntscher, Häbler, Hansen, Street, Böhler, and others. This equipment was distributed to five investigators, who proceeded to break or find fault with most of it, and justifiably so. Early in the program, it was obvious that the femur represented the most propitious field for intramedullary fixation. As a consequence, all efforts were concentrated on improving the equipment for the femur; that for the tibia, radius, ulna, and humerus was temporarily abandoned.

In June 1949, complete sets of intramedullary equipment, either for the diamond-shaped pin or the clover-leaf pattern, were considered adequate and were distributed by the Army to twenty groups of investigators,—three to Army general hospitals, two to Veterans facilities, and fifteen to civilian groups. On their own, some of these workers had proceeded earlier along a similar line of investigation, and contributed their cases and their experience to the development of this project. That this Committee might someday present a report with a modicum of authority, investigators were picked who might be branded as conservatives rather than as zealous enthusiasts. In fact, one investigator was so conservative that he has yet to insert an intramedullary pin; others limited their precursory efforts to pathological fractures due to metastatic carcinoma.

With experience we have become less timid, and have applied intramedullary fixation to a great array of interesting lesions of the femur—namely, fresh fractures and cases of delayed union or non-union—and even to the bridging of defects. Fractures through pathological bone, particularly in Paget's disease, dysplasia, or extreme osteoporosis; or osteotomies to correct bowing of the femora from various pathological entities have been successfully fixed with intramedullary pins. As of January 1, 1950, 398 intramedullary pins have been inserted. To say that the results to date are encouraging would be an understatement. To make a final or conclusive statement would be premature; the project is only well under way. Consequently, this report deals only in generalities, based on impressions, not on facts substantiated by a final analysis of cases.

For those who may be uncertain about proceeding with this technique for fresh fractures of the femur, we offer the following statement: Given the proper indications, intramedullary fixation is the most effective form of therapy for many fractures of the shaft of the femur. That statement must now be modified a bit. This technique, if applied to improperly selected cases, or if inefficiently or unskillfully carried out, offers more possibilities of trouble than any other.

Probably the most common error consists in inserting a pin that is either too long or too short, or too big or too small in diameter. A pin tightly lodged or impinged in an intramedullary canal may result in a very chastening experience. A short or loose pin provides inadequate fixation. For these reasons, intramedullary fixation of the femur necessitates considerable preoperative planning. There is no formula for determining the size of the canal in relation to the length of the bone. In general, young athletic individuals with very large bones usually have rather small canals,—as little as six or seven millimeters in diameter at the isthmus in the middle and upper thirds. The thick cortices encroach upon the canal. A small elderly woman, on the contrary, may have a very large intramedullary canal, so that even an eleven-millimeter pin may provide insecure fixation and permit some degree of rotation and distraction. Consultation with the Committee on Roentgenology of the National Research Council failed to divulge any very accurate method of determining the proper preoperative measurement for the pins. The most accurate technique consists of a scanogram—that is, a full-length, detailed picture of the normal femur—with a pin of known diameter and length strapped to the thigh, parallel to the shaft of the bone. This technique produces a picture with a minimal degree of distortion.

* Report of the Committee on Fractures and Traumatic Surgery, presented to The American Academy of Orthopaedic Surgeons, New York City, February 13, 1950. The Chairman of the Committee was Herman F. Johnson, M.D., and the Secretary was Walter G. Stuck, M.D.

With the exception of two ten-inch by twelve-inch cassettes with built-in grids, the equipment is not expensive. In elderly individuals, a lateral view should be taken to determine the degree of anterior bowing.

As an added precaution, after exposure of the fragments, reamers of nine, ten, or eleven millimeters in diameter can be introduced proximally and distally into the intramedullary canal. If the canal is not sufficiently large to take a reamer of the desired diameter, it can be reamed out until it is. Reamers with ten and one-half inch shafts permit access either from above or below to any part of either fragment. This has made it possible to insert pins of adequate size and strength into husky athletic individuals, who present canals of seven or eight millimeters. No local or general untoward effects have been noted as a result of this method of enlarging the canal. A clearance of one millimeter provides a very tight fit; a clearance of two millimeters provides a medium fit.

A detailed analysis of cases will be carried out next fall. Already, a small series of fresh fractures of the femur, treated by intramedullary pins, have been analyzed in relation to a comparable series treated by closed methods and by internal fixation with plates and screws. Briefly, the results in cases treated by intramedullary fixation were equal or superior in every respect, and the method has the added advantage of a stable, strong fixation that permits early mobilization of joints, early ambulation, and a short period of hospitalization.

A study of the quantity and quality of callus produced in fresh fractures treated by intramedullary fixation presents interesting observations that will be discussed at a later date. Suffice to say that voluminous callus does not develop in all cases treated with intramedullary pins. Even in those with minimal callus, in the critical period of consolidation of soft callus, from the sixteenth to the twentieth week, the intramedullary pin permits the slow, but steady, repair to go forward, undisturbed by lateral stresses and strains. Many of these cases, treated by other methods, could be expected, at best, to show some degree of angulation and perhaps to result in non-union. When our cases are finally analyzed, we expect that there will be fewer instances of malunion than occur with closed methods, and probably fewer non-unions than result after other open methods.

In this series, the Küntscher clover-leaf pin, the Hansen-Street diamond pin, and the Lottes flange nail are well represented. There is little choice among the three, each having some advantages or disadvantages. The equipment and the technique for using it can be improved.

Local complications are bound to occur with this technique, particularly bent pins, migration of pins, distraction of fragments, insecure or incomplete fixation, and the complications that may be attendant upon any technique that requires exposure of bones. I know of ten infections. The fresh fractures, with one exception, proceeded uneventfully to union with no untoward local effects. In one very poor result, the original operation was not performed by a member of this group. There was no indication for the use of the pin. It was used in a segmental fracture in the lower third, the middle segment being represented by a number of butterfly-like fragments. Following infection, the middle fragments sequestrated and eventually an amputation was necessary. Extremely comminuted fractures had best be treated by another technique. The use of an intramedullary pin in a fresh, clean compound fracture with minimal soft-tissue damage is also subject to considerable question. Certainly the pin is contra-indicated if a greater potential of infection is presented. Probably initial experiences with intramedullary pins should be limited to short, oblique, or transverse fractures which are in an area three inches below the lesser trochanter or six inches above the adductor tubercle. This limits the field to about one in every four fractures.

Massive fat embolism may be the big bugaboo that causes some surgeons to view intramedullary pins with reserve. To date, I do not know of a single case of massive fat embolism, much less a fatal one. However, the law of averages suggests that we have been extremely lucky in this regard. It would seem probable that there will be the same percentage of fat embolism with intramedullary fixation as with any other method.

Within a year, we hope to know something about intramedullary fixation of the femur, and to present the amalgamated experience and consensus of those who have participated in this project. It is hoped that the equipment will be perfected, and that the technique will be standardized to the point where intramedullary fixation can be generally accepted as a reliable and satisfactory, although not fool-proof, form of therapy for the femur.

EXTERNAL FIXATION OF FRACTURES*

BY HERMAN F. JOHNSON, M.D., OMAHA, NEBRASKA, AND

SIDNEY L. STOVALL, M.D., SAN ANTONIO, TEXAS

Throughout medical history, physicians interested in fracture management have been striving to attain a satisfactory means of treatment which would include all of the necessary requirements of good fracture management, consisting of good reduction with prompt union, and at the same time allow the physiological functions of the body to take place. In addition, the method must be successful, not only in the hands of qualified orthopaedic surgeons, but also in the hands of physicians engaged in traumatic surgery. To date, no such treatment has presented itself.

Great advances in this direction have taken place in the past four decades, having been inspired by World Wars I and II, accelerated transportation facilities, and the high incidence of industrial trauma.

Many different methods of fracture management have been devised to simplify fracture care and to decrease the number of work days lost as a result of injury. Some of these methods have been discarded, while others have stood the test of time and are now playing an important role in our present-day conception of good treatment. We still do not have an answer to this ever-enlarging and difficult problem. However, each new idea increases our knowledge.

The use of external skeletal fixation in fracture management has been employed for many years; however, it was not until the late 1930's and early 1940's that this method of fixation attained a popular position. Its popularity was increased, and even misrepresented, by articles appearing in the press and lay publications. Since then many articles have appeared in the medical literature, advocating this method of treatment. A study was undertaken by the Committee on Fractures and Traumatic Surgery of The American Academy of Orthopaedic Surgeons to evaluate the efficiency and practicability of this method of treatment, in order that its place in the armamentarium of fracture management might be determined.

This study was instituted under the auspices of the late Clay Ray Murray, and was later taken over by Mather Cleveland and Herman F. Johnson. In order that the study might be complete, it was deemed necessary to reach not only orthopaedic surgeons, but also general practitioners. Hence, questionnaires were sent to all members of The American Academy of Orthopaedic Surgeons, as well as to members of The American Association for the Surgery of Trauma. It was further felt that, in order to obtain the opinions of a representative group of general practitioners, the same questionnaire should be sent to all members of one of the state medical associations. Since Iowa was considered to be a representative state, questionnaires were sent to the members of its medical association, with the realization, however, that many of the questionnaires would be received by physicians limiting their practices to other fields.

The questionnaires requested the following information:

1. Have you, personally, used any method of external skeletal fixation, such as the Stader, Roger Anderson, Haynes, Clayton, or any other type splint employing an external bar for immobilization in the treatment of fractures?
2. What is the most satisfactory type splint you have used?
3. On what type fracture do you think this splint is most satisfactorily employed?
4. How many cases have you treated in this manner?
5. Are you still using this method of treatment?
6. If you have discarded this method of treatment, briefly explain why.
7. What do you consider to be the advantages and disadvantages of this method over other methods of handling?
8. What complications have you observed resulting from this method of treatment, either in your own cases or those seen in consultation?

From the 3,082 questionnaires posted, replies were received in 768 instances, 603 of the correspondents being members of The American Academy of Orthopaedic Surgeons, and 165 being general practitioners. Of those replying, 373 or 48 per cent. had had no direct experience with this method of treatment; their answers have been excluded from this report. There remained 395 replies which have been considered for analysis in evaluating this method of treatment. These 395 replies have been subdivided into three groups, as follows:

Group I comprised those surgeons who had found this method of treatment to have a definite place in fracture management. Within this group there were 108 replies or 27.34 per cent.

Group II comprised those surgeons who had found this method of treatment inadvisable, except in rare and selected instances. Within this group there were 116 replies or 29.36 per cent.

* Preliminary report of the Committee on Fractures and Traumatic Surgery, presented to The American Academy of Orthopaedic Surgeons, New York City, February 13, 1950. The Chairman of the Committee was Herman F. Johnson, M.D., and the Secretary was Walter G. Stuck, M.D.

TABLE I

CASES REPORTED TREATED BY EXTERNAL SKELETAL FIXATION *

Group	No. of Cases					Total
	10 or Less	11–25	26–50	Over 50	Not Given	
I	24	20	18	39 51–100 13 101–500 21 501–1000 2 Over 1000 3	7	108
II	45	23	25	12	11	116
III	85	35	17	12	22	171
II and III	130	58	42	24	33	287

* The number is only approximate, as in many instances accurate records were not kept.

Group III comprised those surgeons who had at one time used this method of treatment, but have discarded it completely. Within this group there were 171 replies or 43.29 per cent.

In order to determine whether or not this method had been given a fair clinical trial, it was necessary to analyze the number of cases treated by the members of each group (Table I).

As seen in Table I, over 50 per cent. of the surgeons in Group I had treated a minimum of twenty-five cases each, while 36 per cent. reported a series of over fifty cases each. In three instances as many as 1,000 cases were reported. Conversely, within the groups reporting unfavorable results, only 32 per cent. had treated a series of twenty-five or more patients and only 8.1 per cent. had treated 100 or more patients. It may be asked whether better results might not have been achieved if some of the surgeons in Groups II and III had had more experience and had given this method a longer trial. However, twenty-four surgeons in the combined groups reporting unfavorably had treated fifty or more patients each, seventeen of these with a series of 100 patients or more. These results should be significant, and the reasons for their disapproval are worthy of note. The consensus in this group was that as good or better results were obtainable by other methods, which these physicians felt were less time-consuming, less difficult mechanically, and attended by fewer of the complications of infection, poor reduction, and immobilization, as well as malunion or non-union.

A study of the advantages listed in the questionnaires showed that more secure and adequate immobilization was listed as the leading factor. Other important advantages reported were early ambulation, shorter period of hospitalization, simplicity and speed of application, reduction of nursing care, and early motion of joints. The lesser advantages included the maintenance of bone length, absence of non-union, absence of distraction, minimum surgical risk, and the reduced period of time required for application. A shortened period of disability was not presented as one of the advantages.

Leading the disadvantages was soft-tissue infection at the pin sites. This was given as the chief cause for discontinuing the use of external skeletal fixation, and was also listed as the chief disadvantage by those who had found this method to be of use in fracture management. Ring sequestra and osteomyelitis were presented as the second disadvantages, followed by non-union. Other disadvantages included mechanical difficulty, pain, conversion of a simple fracture into a compound one, difficulty in obtaining and maintaining reduction, distraction, and inadequate immobilization.

Only 108 correspondents found this method of treatment to have a definite place in fracture management, while 287 who had used this method infrequently or had used but later discarded it, felt that this treatment held no advantage over other methods. This in itself refutes the practicability of external skeletal fixation as a standard method of treatment, although it has a definite place in orthopaedic surgery only when used under the direction of those physicians having a thorough knowledge of the anatomy, physiology, and surgical principles involved.

It is recommended, therefore, that any individual who contemplates using this method of treatment acquire special training under the supervision of an individual who has treated at least 200 cases by this method; its use by physicians without adequate training is not advocated.

This is a preliminary report; further investigation of this problem is being undertaken, and a comparative study of this method with various means of internal fixation will be made.

Book Reviews

A Practice of Orthopaedic Surgery. Ed. 3. T. P. McMurray, C.B.E., M.B., M.CH., F.R.C.S. (Edin.). London, Edward Arnold and Company, 30 shillings; Baltimore, The Williams and Wilkins Company, 1949. $8.00.

This text of the late Mr. McMurray of Liverpool, which is now in its third edition, has definitely established itself in the minds of orthopaedic surgeons in the United States as a sound and well balanced short book on the problems of modern-day orthopaedic surgery. As is to be expected, there is a difference of opinion between the teachings of a conservative orthopaedic surgeon in Great Britain and the orthopaedic surgeons of the United States. Controversial subjects, perhaps wisely, are touched on lightly or not at all. To the orthopaedic surgeon looking for information, this may seem to be an omission; however, for the student learning orthopaedic surgery for the first time, it is probably best that these subjects are not dealt with in too much detail. The failure to mention nailing of the slipped upper femoral epiphysis is an example of omission.

The first two chapters, which describe the examination of the patient and give information on braces and apparatus, are excellent. There are exceptionally good sections on nerve injuries, tumors, internal derangements of the knee, and tuberculosis. In comparison to its incidence in the United States, too much emphasis is placed on tuberculosis, but this may not be true for Great Britain.

The disorders of the low back, so frequently seen in private and clinic practice, are given a minimum of space; particularly is this true for the discussion of ruptures of the intervertebral disc. Discussions on the treatment of club-foot and the stabilization of feet are somewhat incomplete, with no mention of the wedge-cast method of Kite for club-foot or the operative procedures of Hoke and Lambrinudi for stabilization.

It seems to the reviewer that a chapter should have been devoted to old fractures and bone grafts,—subjects which have an important place in the reconstructive work of the orthopaedic surgeon. There is no one section on physical medicine or rehabilitation. This is rather surprising, in view of the large rehabilitation centers established in Great Britain during the past War, from which our military surgeons learned so much.

The book is compact, well printed, and on good paper. The illustrations on the whole are good; however, there are some poor photographs and x-ray reproductions. The black-on-white type of x-ray reproduction is certainly to be commended.

The book gives a definite impression of emphasis on conservative surgery and operative procedures of the author's choice. However, it contains a plentiful amount of valuable information, presented in a clear, concise manner, and should be in the library of every general practitioner and orthopaedic surgeon.

Tumores de los huesos. Diagnóstico y tratamiento. José Alberto Piqué y Fritz Schajowicz. Buenos Aires, Librería y Editorial "El Ateneo", 1948.

These authors, with extensive experience in Buenos Aires as well as in the European clinics of J. Erheim and V. Putti, present in a ninety-page treatise a concise summary of present knowledge of the common bone tumors. Although they list a large bibliography, they state that questionable concepts have been put aside in order to clarify the knowledge of bone tumors for the general surgeon. They emphasize the need for all methods of examination, laboratory studies, and finally histological study of the biopsy specimen.

After a discussion of the North American Classification of 1939, the Classification of Brachetto-Brian of 1946 is considered. In the latter, bone tumors are classified in groups according to the tissue of origin,—that is (1) tumors arising from the bony skeleton; (2) tumors of reticulo-endothelial origin; (3) tumors of hemopoietic origin; and (4) tumors arising from vascular connective tissue. The authors conclude that many subgroups should be abandoned. They discuss, in considerable detail, those members of the benign group of tumors and also the malignant bone tumors.

In a concluding chapter, metastatic tumors are presented. Appended to the general discussion are twenty pages of excellent photographs, roentgenographic reproductions, and photomicrographs, illustrating all of the tumors included. An extensive bibliography is listed for each subject.

Die Überlastungsschäden des Skelettsystems (Weight-Bearing Damage to the Skeletal System). Dr. Med. Hans Werthmann. Bern, Hans Huber, 1948.

A very broad topic is compressed into the forty-six pages of this book. It is, therefore, unavoidable that the subject is treated largely from a general point of view and that specific clinical situations are wanting. The comparison of the physical properties of the human tissues constituting the locomotor apparatus and the strength of material of inanimate structures is discussed in more or less cursory fashion, confined largely to references and general definitions. Nevertheless, we find many pertinent points emphasized, including the sites of preference for ligamentous static strains, the effect of static stresses on bone formation,

and absorption, such as the Loser absorptive zones. The sections on differential diagnosis are more enumerative than differentially detailed, although an effort has been made by the author to treat this aspect of the subject as thoroughly as the space permits. On the whole, the value of the book lies in its being a compendium rather than a text, especially since a rather voluminous bibliography is appended.

To make up for a lack of specific clinical data, the author presents a number of interesting roentgenograms of such conditions as march fractures, static calcaneal spurs, static periosteal reactions in general, Kienböck's disease, osteochondritis of the femoral head, Osgood-Schlatter disease, and Sudeck's atrophy. In addition, there are a few photomicrographs which show callus formation and halisteresis.

The book should be useful for the general practitioner, since it contains a good deal of fundamental information.

POLIOMYELITIS. Papers and Discussions Presented at the First International Poliomyelitis Conference. Compiled and Edited for the International Poliomyelitis Congress. Philadelphia, J. B. Lippincott Co., 1949. $5.00.

The First International Poliomyelitis Conference was sponsored by the National Foundation for Infantile Paralysis is an effort to evaluate the progress made by medical science in the study of infantile paralysis during the past decade and to plan for future studies which might be made on an international scale. This was the first time that information on this disease had been exchanged so extensively. Forty-three nations were represented by official delegates and many by representative scientists as well; and one section of the book (the Tenth Session) is devoted to reports made by these official delegates concerning laboratory and clinical progress abroad.

The program of the Conference was planned in ten Sessions devoted to the following subjects: "The Importance of Poliomyelitis as a World Problem", "Poliomyelitis: Pathogenesis of the Early Stage", "The Management of Poliomyelitis: The Early Stage", "Poliomyelitis: The Convalescent Stage", "The Management of Poliomyelitis: The Convalescent Stage", "Problems of Rehabilitation", "Bulbar Poliomyelitis", "Immunology and Chemotherapy in Poliomyelitis", "Public Health Aspects of Epidemic Poliomyelitis", and "Poliomyelitis Throughout the World".

The proceedings of the Conference were carefully recorded, and this volume is complete in presenting not only the papers of the principal speakers, but also the discussion of the Panel Members at each Session.

This book is valuable for physicians and surgeons called upon to deal with the disease in its early stage or with the resulting deformities.

UNTERSUCHUNGEN ÜBER DEN LUMBALEN UND CERVIKALEN WIRBELBANDSCHEIBENVORFAL. Prof. Dr. F. Reischauer. Stuttgart, Georg Thieme, 1949.

In this monograph on injuries of the lumbar and cervical intervertebral discs, Reischauer follows rather closely in the footsteps of Schmorl. He believes that degeneration is present in practically all instances; damage is rarely observed in a sound disc. The resistance of a normal intervertebral disc is often greater than that of the surrounding bone. Rupture of the intervertebral disc in persons under twenty years of age is rare and is only seen in the presence of a hypoplastic constitution.

In 55 per cent. of the cases, the beginning of neurological symptoms occurs between twenty and forty years of age. Roentgenographic evidence of such damage is an eccentric change in the neural foramen, narrowing of the foramen, and later spondylitis on the anterior margin of the vertebra and in the foramen. Anatomical findings of injury to the intervertebral disc are much more common than clinical symptoms. Intervertebral-disc injury in the cervical region is only 5 per cent. as frequent as in the lumbar region. In the cervical region, osseous proliferation about the vertebral margin is the result of a periosteal tear occurring with the prolapse. Symptoms are usually the result of pressure on nerve roots. Sensory changes are more common than motor changes. Meningeal symptoms may be found with acute intervertebral prolapse, which is seldom the result of trauma. When acute neurological symptoms are present, the epidural injection of 50 cubic centimeters of 1 per cent. procaine is helpful.

The clinical, roentgenographic, and laboratory findings in such injuries in both the lumbar and cervical region are described, as well as the operative procedure for removal of the disc.

MASSAGE AND REMEDIAL EXERCISES IN MEDICAL AND SURGICAL CONDITIONS. Ed. 8. Noël M. Tidy. Bristol, England, John Wright and Sons, Ltd., 25 shillings, 9 pence; Baltimore, The Williams and Wilkins Company, 1949. $5.25.

This is a popular text for use in schools training physical-therapy technicians. It is also of value to the physician or surgeon who is interested in the details and techniques of massage and exercise for all common conditions in which such treatment is indicated. The methods described are generally accepted and up-to-date.

ROENTGEN DIAGNOSIS OF THE EXTREMITIES AND SPINE. Ed. 2 (Annals of Roentgenology: A Series of Monographic Atlases, Volume XVII). Albert B. Ferguson, M.D. New York, Paul B. Hoeber, Inc., 1949. $15.00.

The second edition of Dr. Ferguson's exhaustive study of roentgen diagnosis of the extremities and the spine has been considerably expanded. Two chapters have been added on Specific Tumors and Primary Bone Malignancy, which according to the author are the results of his ten-year study of material at the Registry of Bone Sarcoma. Particular attention is paid to osteogenic sarcoma, Ewing's sarcoma, and multiple myeloma. The final chapter on the spine now includes more detailed diagnostic material, which will be of interest to the roentgenologist, as well as to the orthopaedic surgeon.

As was the case with the earlier edition, the reproductions of the roentgenograms are excellent, and a fact which should make them doubly useful is the presence of the descriptive text immediately below each illustration, with accompanying case history.

LUXACIÓN CONGÉNITA DE LA CADERA. TRATAMIENTO INCRUENTO (Non-Operative Treatment of Congenital Dislocation of the Hip). Agustin A. Salvati. Buenos Aires, Editorial "El Ateneo", 1948.

In this monograph, Dr. Salvati has considered all aspects of congenital dislocation of the hip with a complete review of the literature. The study was based particularly on the observation of over four hundred congenital dislocations at the Infants' Hospital (*Casa Cuna*) in Buenos Aires.

The hip always shows anomalies in development. In the milder cases, the articular relationships may be relatively normal. The author describes methods of measurement from roentgenograms of the pelvis for making an early diagnosis and for estimating the degree of displacement. He divides the hip condition into subluxation (with defect of support) and dislocation.

The use of contrast media for arthrograms is advised. This is particularly helpful in determining the factors which interfere with reduction and in determining when operative treatment should be used. The chief difficulties in reduction are dysplasia of the acetabulum, anteversion of the neck, interposition or adhesions of the capsule, and short ligaments and muscles. There are many variations of the original techniques of reduction of Paci and Lorenz.

Up to 1945, the author used the Lorenz manoeuvres and postreduction positions exclusively; since then he has simplified the procedures somewhat. Before reduction, rest in bed is of value. Continuous traction is rarely necessary. Reduction should be accomplished with a minimum of manipulation and as smoothly and gently as possible. This is done by the Lorenz method. Immediate verification of reduction should be made with roentgenograms. The hip is then put in plaster in 110 degrees of abduction, slight flexion, and 90 degrees of external rotation; the child usually remains in this position for three months. In anteversion of the neck, improvement often occurs in this position. After three months, the hips are brought into less abduction and rotation and this position is maintained for three months more.

The author reviews his own experience and that of others in treating early subluxation by splints, such as Putti's. Often redislocation occurs after such treatment. The use of reduction manoeuvres and of plaster casts has helped to develop a more nearly normal hip joint.

In unilateral dislocation, the so-called normal hip always shows developmental changes. Only 18 per cent. of the hip joints on the unaffected side failed to show noteworthy changes. Both hips are placed in plaster in all cases, and the plaster is maintained even in cases of so-called unilateral dislocation. Stimulation is begun on the muscles about the hip when the plaster has been removed; later, exercises are given. The author feels that abduction splints are of value for night wear after the plaster has been removed. In unilateral dislocation, walking is permitted soon after the plaster has been removed, if the femoral head is well placed. Walking is delayed if there is anteversion, poor muscles, or articular stiffness. Abductions should be equal on both sides. Roentgenographic and clinical review should be carried out frequently during immobilization and after the child is walking. The older the child before treatment is begun, the poorer the anatomical and functional results.

The author has reviewed the histories of twenty-five spontaneous cures of dislocation of the hip, and has reported one of his own. This is an excellent review of this difficult orthopaedic problem.

TRATAMIENTO DE LA LUXACIÓN CONGÉNITA DE LA CADERA. José Enrique Rivarola y José Alberto Piqué. Buenos Aires, Editorial "El Ateneo", 1948.

In this monograph, Dr. Rivarola and Dr. Piqué discuss the treatment of congenital dislocation of the hip in late childhood and in adult life. The clinical material was obtained from the surgical service of the Children's Hospital in Buenos Aires and from the private practices of the authors.

The pathological condition at various ages is reviewed. Arthrography with contrast medium, the patient being under anaesthesia, is advised in these older children to show the state of reduction and to determine when surgical intervention is required. "Nitasom" is used, mixed with 50 per cent. of a 1 per cent. solution of novocain. Two cubic centimeters is adequate in small children. In older children, up to 8 cubic centimeters is used; no serious reactions have resulted.

Seven hundred and sixty-eight patients with congenital dislocation were studied; 337 were treated by non-operative means. A good result by manual reduction depends upon the degree of change in the hip. Walking may lead to functional adaptation or to wasting away of the acetabulum. If arthrography does not show that the dislocation is irreducible, manual reduction can be attempted. In fifty of the 337, the dislocation was found to be irreducible; forty of these children were five years of age or older. Eighty-two hips became redislocated after closed reduction.

The development of the hip joint after reduction varied greatly. The results changed with time. A physiological cure cannot be obtained in children over five. The femoral head is flattened and the acetabulum is irregular. Good function can be obtained, but degenerative arthritis follows articular incongruence and instability. The results were poorer with each year of age. A good result was obtained in 71.36 per cent. in unilateral dislocation; in 54.53 per cent. in bilateral dislocation. After manual reduction, children are kept in the first Lorenz position for three to four months; in the second position for three months. In older children the total period in plaster is not more than four months.

The various operative procedures for residual subluxation are reviewed. Twenty-five operations were performed on the roof to correct subluxation; the ninety-three remaining subluxations were not treated surgically. Seven intra-articular operations were performed. In chronic slight subluxation, periodic roentgenograms are advised. If the subluxation increases, an osteoplastic procedure should be considered. In severe anteversion, the roentgenogram will show the femoral neck as a continuation of the shaft. If over 35 degrees of anteversion is present, osteotomy is advised. Better results followed subtrochanteric than supracondylar operation.

The accidents in non-surgical treatment are reviewed. Fracture of the femoral neck occurred twenty-two times in 489 hips. Supracondylar fracture occurred twenty-one times. During and after plaster immobilization, vitamins, calcium, and ultra-violet light are given. Skeletal traction before reduction gave poor results. Open reduction is indicated after failure of orthopaedic treatment, if the child is over nine years of age and if arthrograms show obstruction to reduction. Twenty-nine open reductions were performed. Osteotomy was used as a palliative procedure, as a prop, to decrease flexion, and to help the gluteal muscles. One hundred and ninety-eight dislocations in adults were seen between 1928 and 1948. In seventy-nine, non-operative reductions had been performed. Treatment is always palliative. Some need no treatment. Closed reduction, braces, and physical therapy are often used. Open reduction usually gives poor results. Plastic procedures, arthrodesis, osteotomies, and obturator neurectomy are discussed.

This monograph is a veritable mine of information concerning the difficulties encountered in older children with congenital dislocation of the hip.

MODERN SURGICAL TECHNIC. Ed. 2. Max Thorek, M.D., LL.D., Sc.D., F.I.C.S., F.B.C.S., D.C.M. Philadelphia, J. B. Lippincott Company, 1949. Four Volumes and Index Volume, $72.00 for the set.

The necessary limitations of a book review must prevent an adequate description of these most valuable and complete volumes. It may be of interest to the reader to know that the first edition went through eleven printings, and that a one-volume edition was published for use by the armed forces during the War. There are also Spanish and Portuguese editions.

Operative procedures of all types are fully described and illustrated; indeed, one would gather from only a cursory review that the sum total of surgical procedures now in everyday use has been included. A good deal of attention is directed to both preoperative and postoperative care, those two vitally important companions of surgery. The general tone of the books would seem to indicate a trend in Dr. Thorek's opinion that the day of specializing in a narrow field of surgery has passed, or is passing, and that today's surgeon must be prepared for a wider field of endeavor.

Volume II deals specifically with orthopaedic surgery, and has been prepared by Dr. Kurt Eichelbaum and Dr. Horace E. Turner. The authors do not claim to have covered the field completely, but standard problems and procedures are well described.

The value of such a work cannot be denied; particularly should attention be called to the manner in which it has been planned. Both the Tables of Contents in the separate volumes and the Index Volume itself are most useful and well done, and the drawings and pictures throughout all four volumes are excellent.

NEW HOPE FOR THE HANDICAPPED. THE REHABILITATION OF THE DISABLED FROM BED TO JOB. Howard A. Rusk, M.D., and Eugene J. Taylor. New York, Harper and Brothers, 1949. $3.00.

The concept of rehabilitation of the handicapped, preached with such brilliance during the first World War by Sir Robert Jones in England and by Professor Konrad Biesalski in Germany, has found vigorous expression in this volume, in which the fruit of intensive work during World War II is presented in a form which must appeal to both layman and physician. In his introduction, Bernard M. Baruch summarizes the scope of the book thus:

"The authors of this book have told the story of the remarkable advances made in rehabilitation in the military services and Veterans Administration. The challenge which they present on making such oppor-

tunities available to the far greater number of disabled civilians is one that we cannot ignore. The investment in rehabilitation is an investment in the greatest and most valuable of our possessions, the conservation of human resources."

Many of the chapters begin with a case history which dramatizes the central thought. Thus, in the first, entitled "Ability or Disability", Sergeant Harold Russell, who "had learned to replace his disability with capability, to create in cold, mechanical steel the power to lead an active, useful life", is contrasted with a civilian amputee, who, because of inadequate training, never learned to adapt himself to his disability. The authors concluded the chapter thus:

"Preventive and curative medicine and surgery have made great advances. The third phase of medicine which takes the patient from the bed to the job—rehabilitation—has been neglected. Comprehensive rehabilitation programs have been established in the armed forces and the Veterans Administration. The disabled civilian, in a democracy, deserves the same opportunity."

From cover to cover, this book is preaching a message,—the importance of conservation of manpower by adequate care and training of the disabled. Term it propaganda if you like, but it is propaganda inspired by a passionate desire to help the huge numbers of disabled—civilian as well as military—to re-establish themselves as happy, productive members of the community. The narrative style makes the book delightful reading; even the statistics are presented in a form which makes them exciting. It is the kind of book which once begun, the reader hates to put down until it has been read to the last page. It unquestionably raises rehabilitation to an important phase of medical treatment.

FUNDAMENTAL CONSIDERATIONS IN ANESTHESIA. Charles L. Burstein, M.D. New York, The Macmillan Company, 1949. $4.00.

There has long been need for a book which would make available to surgeons and anaesthesiologists the knowledge of physiology and pharmacology bearing on situations encountered during surgical anaesthesia. *Fundamental Considerations in Anesthesia* is designed to meet this need. Based chiefly upon observations made in the surgical clinic at the Bellevue Hospital and in the research laboratories of the College of Medicine of New York University, the book is concerned with the role of the autonomic nervous system, especially in the production of disturbances and reactions in the course of anaesthesia and operation. Some of the subjects discussed are: respiratory disturbances and the role of autonomic reflexes in their production; shock mechanisms and the management of patients in the state of surgical shock; and circulatory disturbances, such as cardiac arrythmias and the effects of spinal anaesthesia upon the circulation.

The book is well printed on excellent paper. The drawings and diagrams are clear and well reproduced. A list of references is included at the end of each chapter.

This excellent book should be included in the libraries of surgeons and anaesthesiologists, as well as the libraries of hospitals and medical schools.

OPERATIONS OF GENERAL SURGERY. Ed. 2. Thomas G. Orr, M.D. Philadelphia, W. B. Saunders Company, 1949. $13.50.

This second edition of Dr. Orr's well-known work contains much new material and excellent illustrations of new techniques. To readers familiar with the first edition, no mention need be made of the general excellence of this volume, written as it has been by a surgeon of much practical experience as well as a teacher of other surgeons for many years.

Of particular interest to orthopaedic surgeons will be those sections on amputations (Callander's technique has been described), tendons and tendon sheaths, and operations upon muscle, fascia, and bursa. Dr. Orr follows a very readable method in his descriptions,—first summarizing the indications for operation, and then following with descriptions of the most important operations, their dangers, and safeguards against these dangers. The step-by-step illustrations add greatly to the understanding of the text.

Chapters on "Wound Healing" and on the "Treatment of Fresh Wounds" have been included; the technique of wound closure with steel wire is discussed in the chapter on "Abdominal Incisions".

THE MEDICAL ANNUAL. A YEAR BOOK OF TREATMENT AND PRACTITIONER'S INDEX. Editors: Sir Henry Tidy, K.B.E., M.A., M.D. (Oxon.), F.R.C.P., and A. Rendle Short, M.D., B.S., B.Sc., F.R.C.S. Bristol, England, John Wright and Sons, Ltd., 1949. 25 shillings, 9 pence.

The most recent edition of the *Medical Annual* contains a review of medical and surgical developments in Great Britain during 1949. As in previous editions, the subject matter has been presented in alphabetical arrangement, so that work pertaining to a specific field may be included under several different headings, in various parts of the volume.

The sections relating to orthopaedic surgery were, as before, prepared by the late T. P. McMurray, Emeritus Professor of Orthopaedic Surgery at the University of Liverpool. He presented short discussions of

conservative surgery for bone tumors, recurrent dislocation of the elbow joint, fractures of the tibial shaft, paraplegia following injuries of the cervical spine, painful shoulder, and the use of streptomycin in tuberculosis of the bones and joints.

As addenda the book contains brief descriptions of recent pharmaceutical preparations and appliances, and a list of British and American medical books published during the year.

The Annual, now in its sixty-seventh year of publication, is comprehensive in its subject matter and a useful reference book.

A Companion in Surgical Studies. Ian Aird, Ch.M., F.R.C.S. Edinburgh, E. and S. Livingstone, Ltd., 63 shillings; Baltimore, The Williams and Wilkins Company, 1949. $15.00.

This interesting book has been written by a surgeon and teacher who apparently has sympathy and understanding for the many problems which confront the busy student and practitioner of surgery. From the pedagogical point of view, it leaves no stone unturned in attempting to clarify, through good writing and careful presentation, all of the basic problems of surgery.

Mr. Aird is the fortunate possessor of a remarkably concise and simple writing style. This fact, plus his years of teaching, go toward making the book a valuable one. The writer himself regards the book as a kind of springboard from which the student may project himself into the deeper reaches of surgical literature, as well as into the more everyday problems of clinical surgery. Anatomical details required for the understanding of operative procedures and the principles underlying treatment are given much space. Attention is also paid to pathological problems which may be met by the surgeon. Two main types of print are used,—one for that material which requires close study, and the other for those sections which are suitable for more cursory attention.

Unfortunately for the readers of *The Journal*, there is no section devoted to orthopaedic surgery or fractures, the writer having felt that this specialized field need not be studied by the person seeking general surgical information.

Medical Etymology. The History and Derivation of Medical Terms for Students of Medicine, Dentistry, and Nursing. O. H. Perry Pepper, M.D. Philadelphia, W. B. Saunders Company, 1949. $5.50.

With a rare sympathy for the student who, early in his course, becomes submerged in strange medical terms, Professor Pepper has prepared this practical little book. The acquiring of a medical vocabulary has always been difficult; the author calls attention to the fact that it is doubly difficult today, for few of the younger students have any knowledge of the classical languages, which is so necessary to the full appreciation of medical terminology.

About 4,000 terms are included in this small volume; they represent most of the roots which the student will encounter. Their derivations are clearly shown, as well as their definitions.

While the book is of special value to those with little background of foreign languages, it is also a fascinating book for all who are interested in the semantics of medical terms.

Cancer: A Manual for Practitioners. Ed. 2. American Cancer Society (Massachusetts Division) Inc., Boston, 1950.

This second edition of a well recognized book, first published in 1940, has been prepared by the Committee on Publication of the American Cancer Society (Massachusetts Division) for general distribution to physicians in the State. Advance in the knowledge of cancer and its treatment in the last decade has made thorough revision necessary. All chapters have been rewritten by those chosen by the Committee to present the different subjects, and several new chapters have been added.

Some of the more general chapters are of interest to all,—such as "Modern Cancer Research", "The Pathology of Malignant Disease", "Biopsy in Relation to Tumor Diagnosis", and those dealing with the organized programs of cancer control.

Of special interest to readers of *The Journal* is the chapter on "Malignant Tumors of Bone" by Dr. Channing C. Simmons. Following, for the most part, Ewing's classification, he presents briefly but clearly the different types of malignant tumors, giving under each: symptoms, x-ray appearance, diagnosis, treatment, and prognosis.

The details of treatment, whether surgical, roentgen, or of other forms, are not included, since the book is written primarily for the general practitioner, the one who first sees the patient. It should certainly be an aid to him in the diagnosis of cancer and in suggesting the treatment indicated. For this purpose the book is a valuable contribution in the fight against cancer.

Semiología y patología de la articulación de la rodilla (Clinical Picture and Pathology of the Knee Joint). José A. Piqué y Carlos Khoury. Buenos Aires, Lopez y Etchegoyen, 1948.

This monograph is concerned, as the title implies, with the various clinical pictures and pathological conditions found in the knee joint. It is actually a textbook rather than a monograph, and the authors state

in the prologue that the object of the book is to make it easy for students to learn about the knee joint. One excellent point, made on numerous occasions, is the importance of putting the whole clinical picture together when diagnosing a specific knee condition.

The book is well organized and the presentation is orderly. The various aspects of the examination of the knee joint are treated in great detail. The inspection and palpation of the knee from each aspect is described, and the synovial compartments of the knee are described and illustrated. Numerous clinical signs are described accurately. Eleven different signs for tears of the menisci are described, and this section could be reviewed with profit by any orthopaedic surgeon. Additional sections are devoted to the functional clinical examination of the knee, the roentgenographic examination of the knee, and laboratory work which may prove of value in pathological conditions of the knee. Pneumo-arthrography is discussed in some detail.

The principal section of the book (approximately the last half) is devoted to a description of the various pathological processes encountered in the knee joint. Descriptions are given of the various pathological entities, and illustrative roentgenograms are shown. There are no drawings or pictures of the pathological condition, however. In a number of places, important points are brought out which are unfamiliar to the average orthopaedic surgeon. An example of this is the differentiation of the syndrome of Pellegrini, which consists of post-traumatic calcification in the area of the medial epicondyle of the femur, and the fracture of Stieda, which is a true fracture of the medial epicondyle.

Although the book is somewhat elementary for the mature orthopaedic surgeon, nevertheless it contains a great deal of value and presents a comprehensive review of the knee joint.

BOOKS RECEIVED

The Journal wishes to acknowledge receipt of the following books and monographs, which have been sent to the Editorial Department:

La chirurgie du mouvement. Raphaël Massart. Paris, G. Doin et Cie, 1949.

Cirugía de las parálisis espásticas. F. Bastos Mora. José Janés, Editor, 1948.

Frakturen und Luxationen. Lehrbuch für Studierende und Ärzte. Prof. Dr. Arthur Hübner. Berlin, Springer, 1948.

Inmovilizacion. Vendajes, traccion continua, enyesados. Dr. José Pedro Reggi. Buenos Aires, Lopez y Etchegoyen, 1948.

Osteosynthesis with a Long Intramedullary Metal Pin (Küntscher's Method). Emile J. Moeys, Utrecht.

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